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WOOD DUCK RESEARCH IN MASSACHUSETTS 1970-1980

COMMONWEALTH of MASSACHUSETTS
DIVISION of FISHERIES & WILDLIFE

Research Bulletin #19

522/138

WOOD DUCK RESEARCH IN MASSACHUSETTS 1970-1980

or

Son of The Wood Duck in Massachusetts

H W Heusmann
and
Robert H. Bellville

MASSACHUSETTS DIVISION OF FISHERIES & WILDLIFE

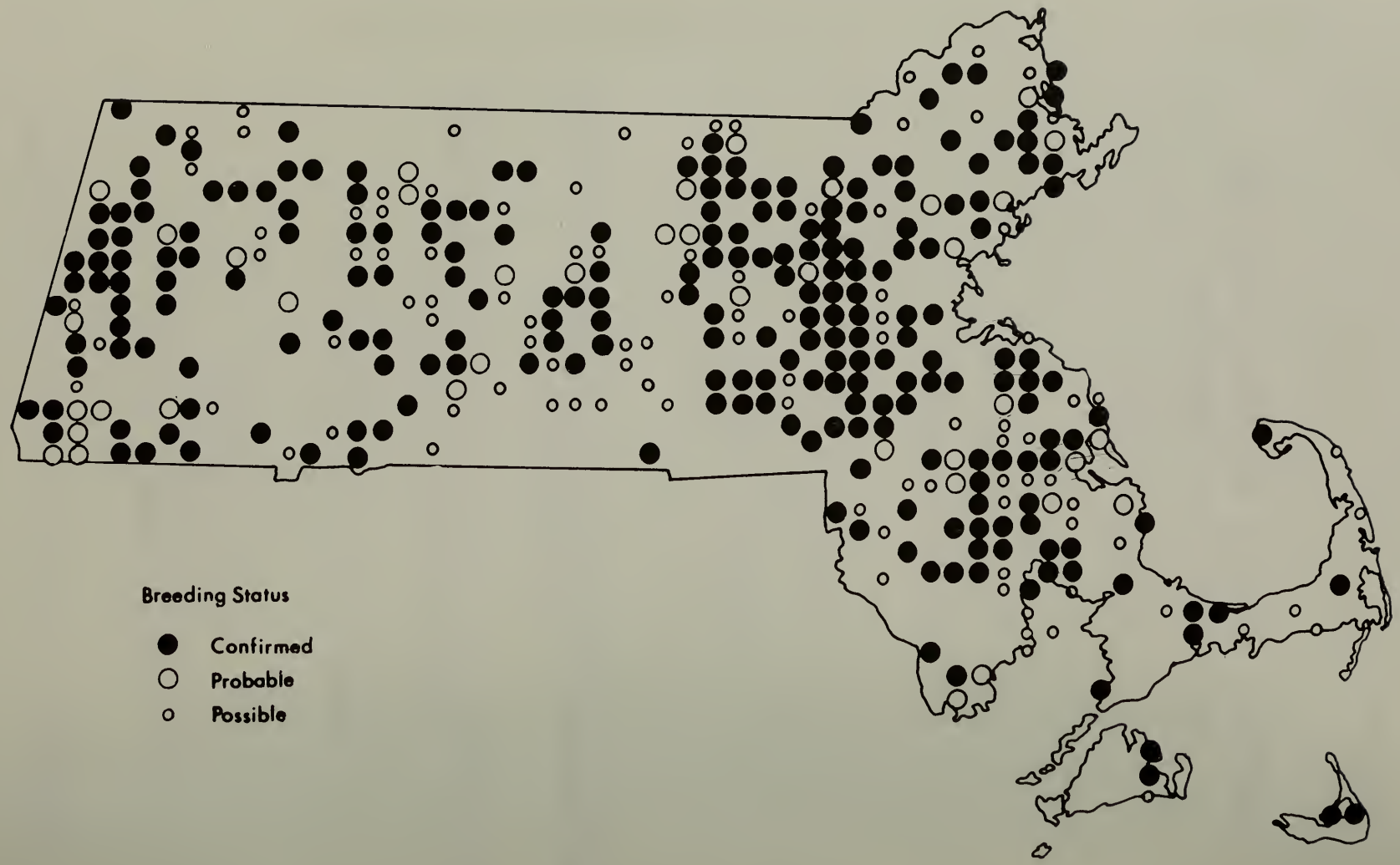
WESTBOROUGH, MASSACHUSETTS 01581
Richard Cronin; Director

RESEARCH BULLETIN 19

1982

FINAL REPORT
Federal Aid in Wildlife Restoration
Project W-42R, Job IV

Publication of this Document Approved by John Manton, Acting State Purchasing Agent.
Form: 12420-64-500-6-81 Est. cost per copy: $1.00



Distribution of the wood duck in Massachusetts, 1971-74 (adapted from Massachusetts Audubon Breeding Bird Atlas), Karen Fogerty.

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FOREWORD

The Wood Duck in Massachusetts, published in 1965, detailed research conducted by the Massachusetts Division of Fisheries and Wildlife from 1949 through 1956. That work remains one of the most comprehensive bulletins on wood duck ecology to date. In 1960, project leader David Grice, alarmed at an apparent decline in wood duck nesting populations, revived the wood duck project and it continued in one form or another for the next 20 years. The purpose of this bulletin is to update the original by David Grice and John P. Rogers.

As a bulletin, this publication is a combination of materials. It is designed to update the status of the wood duck in Massachusetts, summarize research previously reported in a variety of journals and papers, and report findings not previously published. It may be considered an appendix to *The Wood Duck in Massachusetts.* The major emphasis is on research since 1970 when the senior author became the project leader.

Wood duck populations are dynamic and constantly changing. By the mid-1970s, the wood duck population in Massachusetts was probably as high as it ever had been. At the time of this report, however, populations appear to be declining again, perhaps a reflection of a series of early October opening dates for the waterfowl season which exposed wood ducks to increased local hunting pressure.

Wood duck research continues. In 1979, we began a statewide check of 50 areas during the nesting season to determine how much winter indices of box usage varied from actual production figures. In 1980, we began blood sampling birds during preseason banding operations and while checking hunter's bags as part of a flyway-wide study to develop a means of determining the origin of wood ducks by "biological tagging". (Thul *et al.* 1980) The wood duck is one of the most important waterfowl in the state, both as a game bird and a colorful wildlife resident for the nonconsumptive user. We will continue to monitor the status of this bird and work to learn more about its ecology in order to insure its continued well-being.

ACKNOWLEDGMENTS

Many people have contributed to the wood duck project over the last ten years. In our efforts to recall all the names, the first that comes to mind is Peter R. Pekkala. Peter originally worked out of the Northeast District office but each May he was assigned to the waterfowl project, working in the field until October. When Heusmann joined the Division, fresh out of graduate school, Pekkala became his mentor, showing him all the little secrets to field work that textbooks do not divulge. Peter's special talents, though, lay in his inventive genius. When Heusmann asked him to design a device that would automatically color-mark nesting wood ducks, Peter modified a tunnel predator guard with a treadle on the floor and a eyedropper on the roof that dropped a liquid on the duck's back as she entered the box. The device worked beautifully but had to be shelved as Heusmann was unable to find a suitable series of dyes. Heusmann again turned to Peter with the idea of a skylight lid that would deter starlings from using nest boxes. Peter found the materials and designed several styles of lids. He continued to work closely with the waterfowl crew after his promotion to Connecticut Valley District Game Manager.

Two other people closely involved with the wood duck project were James E. Cardoza and Richard G. Burrell, both biologists at Westboro Field Headquarters. Jim worked intensively on the project during the nesting studies of the early 1970s while Dick became involved in the dump nesting work done in the late 1970s. Dick developed the automatic collaring device that eventually replaced Pekkala's device.

Warren W. Blandin, former waterfowl biologist, oversaw the waterfowl project while he was Chief of Wildlife Research. When Warren left, the position was filled by Chet M. McCord.

Other employees involved in our wood duck studies were Ed Jensen, Walter Dauderis, Wayne Lundstrom, Wayne MacCallum, John Bicknell III, James Pottie, G. Christopher Thurlow, Rick Robillard, Tom Early, Sarah Early, Richard Turner, Tom Palmer, Pat DeMarco and Peter Mirick.

John Prouty and Paul Mahoney, game culturists, were involved in the rearing of wood ducks as was Philip Stanton of Upton. Personnel in all five of our district offices erected and maintained boxes and cylinders. We would also like to thank the staff of the Great Meadows National Wildlife Refuge for their continued cooperation as well as Charles and Cynthia Thomas of the Stony Brook Audubon Sanctuary.

The authors gratefully acknowledge the contribution of Ellie Horwitz, Chief of Information and Education, whose encouragement led us

to retrieve a 1973 version of this work which was buried in our files and update it into the present bulletin. Ellie also edited the final manuscript and shouldered the responsibility of getting it published.

Jim Cardoza, Richard Burrell and Peter Mirick reviewed the manuscript and made critical comments.

Printing was done by the students of the Assabet Valley Regional Vocational Technical High School, Marlborough, Massachusetts under the supervision of Jim Underwood and Ed Socha.

Paper was donated by Peter Dowd.

Cover photo by Bill Byrne.

The study was a contribution of Massachusetts Federal Aid in Wildlife Restoration Project W-42-R, job IV.

INTRODUCTION

The wood duck *(Aix sponsa)*, like most species of American wildlife, has been greatly affected by the coming of European man to the North American continent. In Massachusetts, the white man has been altering the landscape and hence modifying wood duck habitat for over 300 years.

The wood duck is a cavity nester and requires mature forests to insure ample nesting sites. During the 200 years between 1650 and 1850, wood duck populations in the Northeast began to decline with the destruction of the original forest by homesteaders. The duck was still common in the Northeast by 1870, but by 1900, the combination of market gunning and continued habitat destruction had decimated the population, leaving the wood duck on the brink of extinction in most of the East. Extensive protection throughout its range followed. The first perceptible increase in the Northeast was reported in 1920, and by 1930 the species was generally re-established throughout the region. By 1938, wood ducks were so common they occupied all favorable range and nesting sites. The birds adapted well to civilization, nesting in front yards, along highways and in town commons. Then in 1938, a hurricane hit the Northeast, blowing down many large trees and consequently destroying wood duck nesting cavities. A population decline of 60 percent was reported in the Concord area the following spring (Griscom 1949).

Concern about a possible lack of nesting sites motivated the Massachusetts Division of Fisheries and Wildlife to undertake a study to determine if nest boxes, in effect giant bird houses, could increase wood duck populations.

The first boxes on the Great Meadows National Wildlife Refuge were erected in 1943. Boxes were erected in other parts of the state in the late 1940s and the results of preliminary investigations indicated that the lack of nest sites did seem to be limiting populations. The Division began a large-scale box erection program in the early 1950s and the wood duck population showed a dramatic increase.

The Division instituted an intensive research program on wood duck ecology from 1948 to 1956. Much of this work centered on the Great Meadows refuge impoundments in Concord. The results of this research were presented in a monograph, *The Wood Duck in Massachusetts*, by David Grice and John P. Rogers, published in 1965.

As early as 1956, however, Grice (1962) noted a decline in the number of yearling female wood ducks using boxes on the Great Meadows refuge. This decline was eventually reflected in other areas of the state as well. Grice (1960) expressed his concern at the Nor-

theast Section of The Wildlife Society's annual meeting. The decline in the population continued into the 1960s. A comparison of nine areas in the Sudbury-Assabet-Concord *(SuAsCo)* watershed system between 1954 and 1963 revealed the magnitude of the decline (Grice 1963a).

1954 - 97 functional boxes - 69 used by wood ducks
1963 - 84 functional boxes - 9 used by wood ducks

In order to compare wood duck nesting success, survival and recruitment from the SuAsCo areas with other sections of the state, eight additional areas of wood duck usage were selected in 1967 for comparison purposes. The areas were increased to 10 by 1969 and included sites in Worcester and Norfolk Counties.

DESCRIPTION OF STUDY AREAS

Great Meadows National Wildlife Refuge, Concord

Grice and Rogers (1965) described the SuAsCo river system and the Great Meadows impoundments as they existed in the early 1950s. The rivers remain as described, characterized by spring flooding, extensive stands of buttonbush (*Cephalanthus occidentalis*) along the edge and assorted aquatic emergents. The impoundments where most of their studies were conducted, however, have changed drastically. A vegetational die-off started in the 1960s and wood duck brood cover decreased by 1964. Cover loss was compounded in March 1968 when a spring flood caused impoundment ice to lift up, tearing loose from its bed most of the emergent vegetation frozen into the ice. The ice also took out a large number of nest boxes. Large areas of open water were created on both impoundments. The lower marsh fared slightly better than the upper, retaining its islands of buttonbush. In addition, the beds of cattail (*Typha spp.*) which occupied the center of the marsh re-established along the lower dike. Lotus (*Nelumbo lutea*) from the upper impoundment became established in the lower one and by the mid-1970s was the dominant plant. Yellow water lily (*Nuphar spp.*) also became abundant but giant bur-reed (*Sparganium eurycarpum*), the dominant plant of the 1950s was eradicated by the flood.

The upper impoundment remained largely open during most of our study but by the mid-1970s, yellow water lily and lotus were providing sparse cover. Water drawdowns during the early and mid-1970s by refuge personnel resulted in the establishment of stands of wild millet (*Echinochloa spp.*) on both impoundments.

The other major change in vegetation from the 1950s was the complete loss of submergent aquatics. This was probably due to two factors. Effluent and leachate from nearby sewage filtration beds resulted in high levels of organic materials and the creation of a floating, ''false bottom'' over much of the impoundments, smothering

submerged aquatic and preventing others from rooting in the unstable substrate. Increased wave action due to the loss of protective emergents may have also been an influence in the loss of coontail (*Ceratophyllum spp.*), water milfoil (*Myriophyllum spp.*), muskgrass (*Chara spp.*), and bladderwort (*Utricularia spp.*), formerly found on the impoundments. On the other hand, the nutrient-rich waters resulted in extensive algae blooms and dense mats of filamentous algae frequently built up on the upper impoundment along the center dike. Duckweed (*Lemma spp.*) and water meal (*Wolffia spp.*) were also common.

Although there was some encroachment along the landward side of the marsh by terrestrial vegetation, the total wetlands area consisted of approximately 68 hectares (170 acres) of deep and shallow marshland with some shrub swamp. Spring water depths averaged one meter (three feet), but by late summer most of the impoundment area was covered by less than 0.3 meters (one foot) of water.

Buttrick Estate Ponds, Concord

This area was located north of the Great Meadows impoundments, immediately across the Concord River. The estate consisted of two impoundments surrounded by several hundred acres of upland hardwoods. The upstream impoundment was an elongated T-shaped pond of approximately 7.3 hectares (18.2 acres). The dominant plants at the time of study were pickerel weed (*Pontederia cordata*) and white water lily (*Nymphaea odorata*). Lotus first appeared in 1973 and was becoming an important cover plant by 1978. The pond also contained scattered clumps of buttonbush and one cove was filled with grassy tussocks. The main submerged plant was water milfoil. Water depth averaged 0.6 meters (two feet).

The second downstream impoundment was oval-shaped, 5.5 hectares (13.8 acres) in size, with a narrow island in the middle. There was little cover on the pond although there was a small stand of cattail on the north side of the island and an area of buttonbush along the north shore. Water depth averaged 0.6 meters.

Estabrook Pond, Concord

This impoundment was located in the Harvard Experimental Forest 1.9 kilometers (1.2 miles) northwest of Great Meadows. It was an L-shaped pond seven hectares (17.6 acres) in size characterized by many stumps cut off at water level. The major aquatics were water shield (*Brasenia schreberi*) and *Sphagnum* moss. White water lily was plentiful and St. Johnswort (*Hypericum* sp.) grew on many of the stumps. The area averaged 0.6 to 0.8 meters (2 to 2.7 feet) in depth.

Greenough Estate, Carlisle

This former estate possessed a three-segmented pond totalling 9.2 hectares (23 acres) of deep marsh and open water. Shrub swamp abutted the marsh at three points and comprised an additional 7.8 hectares (19.6 acres) of wetlands. The area adjoined the Concord River flood plain and was located 5.0 kilometers (3.7 miles) north of the refuge impoundments. Buttonbush and leather leaf (*Chamaedaphne calyculata*) were the dominant woody plants while extensive beds of white water lily covered most of the deep marsh. Bladderwort was the dominant submergent aquatic. Water depths ranged from 0.2 to 1.5 meters (0.75 to 5 feet).

All the above areas were located in the SuAsCo valley watershed. The following areas are located in Worcester, Middlesex and Norfolk Counties:

Ayer State Game Farm Pond, Ayer

This small pond, 3.5 hectares (8.8 acres) was located on the property of a Division pheasant (*Phasianus colchicus*) rearing facility. A breeding flock of wood ducks was maintained there in an enclosed pool between 1972 and 1978. The Nashua River was only a few hundred meters away. The pond was shallow, most of it less than 0.5 meters (20 inches) in depth. There were areas of buttonbush, and the dominant aquatic plants were pickerel weed and spikerush (*Eleocharis* sp.). White water lily was also common.

Breeding Pond, Webster

This area was an artificially-flooded cedar (*Chamaecyparis thyoides*) swamp, 9.2 hectares (23 acres), nearly devoid of standing dead timber except along the east side. Average depth was one meter (three feet). Good brood cover consisting of cattail and grasses existed along the edges while white and yellow pond lily dominated the open water areas. The pond connected directly with Webster Lake.

Chaffins Pond, Holden

Nest boxes were located only in the southwest corner of the pond which was 55 hectares (138 acres). This area was surrounded by upland hardwoods although cedars were numerous around the edge of the pond. Pickerel weed provided late-season cover in the southeast corner, but general brood cover at the time was poor. White water lily and water milfoil predominated in the shallow water areas. Water depth averaged 1 to 1.7 meters (three to five feet).

Fisk Mill Street Pond, Milford,

Water levels on this 6.2 hectare (15.5 acres) pond were controlled by a flashboard dam but averaged one meter (three feet) most of the year. Predominant aquatic plants were white water lily, milfoil and bladderwort. There were scattered stands of pickerel weed. The area was surrounded by hardwood uplands. Good brood cover existed along the brook which flowed into the pond from the north end. An additional 11.9 hectares (30 acres) of shrub swamp was located directly north of the pond.

Long Pond, Rutland,

This was one of four ponds clustered in the Rutland State Forest, it was 15.4 hectares (38.6 acres) in size. Nest boxes were located in the northern end of the pond. The pond was bordered on all sides by well-traveled roads. The only brood cover was a few hectares of tussock marsh at the north end of the pond. Water depth averaged 0.6 meters (two feet) in the section of pond where the boxes were located.

Nipmuc High School Pond, Mendon,

This was a relatively young pond (10 to 12 years) when this study commenced. The dominant feature was flooded timber. Tree swallows (*Iridoprocne bicolor*), starlings (*Sturnus vulgaris*), grackles (*Quiscalus quiscalus*), tufted titmice (*Parus bicolor*) and common flickers (*Colaptes auratus*) nested in natural cavities. There was little herbaceous or shubby brood cover although a flooded sapling swamp existed immediately northeast of the pond. The 4.8 hectare (12 acre) pond was surrounded by upland hardwoods at the north end and open farmland at the south. Much of the fooded timber had died and fallen by 1978.

Spruce Pond, Boylston

This small (1.3 hectares - 3.3 acres) pond was bounded on the north by Route 70 and on the east by Route 140. Water levels fluctuated a meter or more with those of adjacent Wachusett Reservoir and the nest boxes were sometimes flooded. Fair brood cover existed in the form of leather leaf and alder (*Alnus rugosa*) on the edges and several small islands. Water levels varied from one to two meters (3 to 6.5 feet).

Turkey Hill Brook, Paxton

This stream was impounded by a Department of Natural Resources dam forming Eames Pond (51.5 hectares - 130 acres). The pond was characterized by large areas of buttonbush, sparse to dense stands of pickerel weed, and white water lily. Large areas of tussock marsh ex-

isted on both the pond and the brook proper. Route 122 segregated the brook from the pond. Between 1971 and 1973, the water level on the pond was lowered to facilitate road construction and dam repair causing the pond to shrink back to the vicinity of the brook channel. Repairs were completed by 1974 and the area reflooded to 0.5 to 1 meter (1.5 to 3.3 feet) in depth.

Westborough Wildlife Management Area, Westborough

This area consisted of two man-made ponds located 0.7 km. (0.4 miles) apart. One was slightly under a hectare in size (2.4 acres), primarily open but shallow (0.5 to 0.7 meters - 1.5 to 2.5 feet) water, and was surrounded by hayfields. The second, larger pond (2.2 hectares - 5.5 acres) was densely vegetated with white water lily, sedges (*Carex* spp.) rushes (*Juncus* spp.) and various grasses. It was slightly shallower than the first pond and abutted a wooded hillside with an abandoned gravel pit on the west side and an abandoned field on the east. The ponds were located near the Assabet River.

Bristol-Blake Complex, Norfolk

The state reservation area consisted of 27.6 hectares (69 acres) of wetlands. An open pool was connected by water control structures to two areas of deep marsh where pickerel weed predominated and edges consisted of a shrub swamp zone where the dominant plant was red maple (*Acer rubrum*). All boxes were located in the deep marsh areas. Water depth was less than a meter. Many sections of the pond had false bottoms that rose during summer months. The other section of the complex was located 1.7 km. (1.1 miles) west of the reservation on the Norfolk Correctional Institute grounds. This area was formed by the impoundment of Stony Brook and the headwaters of Stop River and consisted of an area of open water at the impounded end followed by deep marsh and flooded timber upstream. The area totaled 55 hectares (143 acres). (Figure 2)

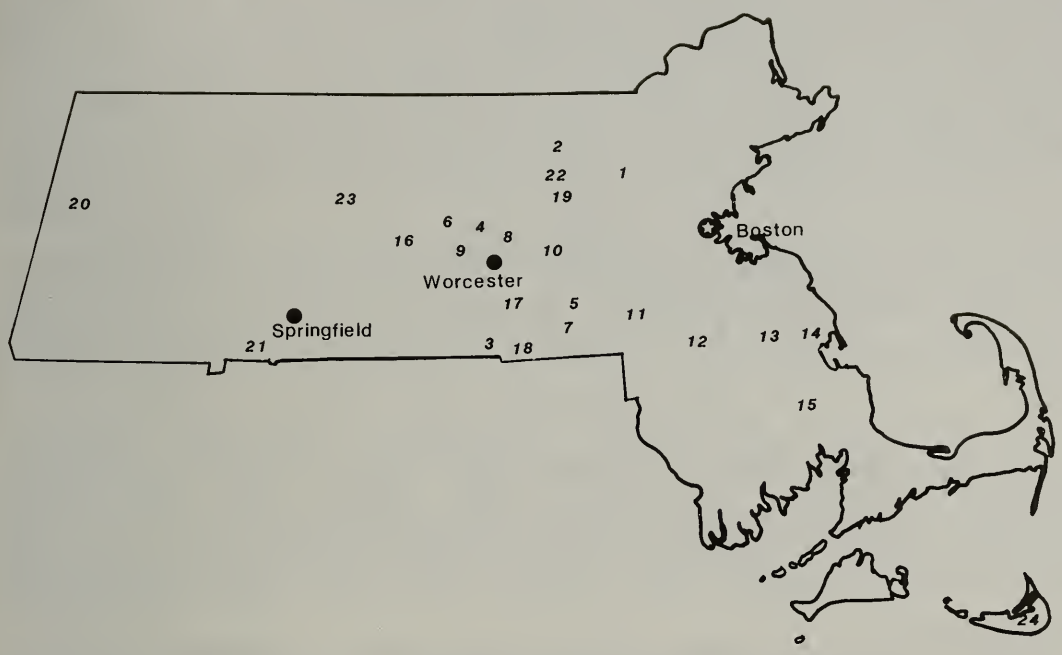


Figure 2. Location of wood duck areas.

1. Great Meadows National Wildlife Refuge, Buttricks Estate, Estabrook Pond, Concord; Greenough's Estate, Carlisle.
2. Ayer Game Farm Pond.
3. Breeding Pond, Webster.
4. Chaffin's Pond, Holden.
5. Fisk Mill Street Pond, Hopedale.
6. Long Pond, Rutland.
7. Nipmuc High school Pond, Mendon.
8. Spruce Pond, Boylston.
9. Turkey Hill Brook, Paxton.
10. Westborough Wildlife Management Area, Westborough.
11. Bristol Lake Complex, Norfolk.
12. Meadow Lea Bog, easton.
13. Great Cedar Swamp, Hanson.
14. Kaplowsky's Bog, Duxbury.
15. Atwood's Bog, Mazzela's Bog, Carver.
16. Cusky's Pond, New Braintree.
17. Sutton System, Sam Kator's Pond, Sutton.
18. Hayden Pond, Easterbrook Pond, Douglas.
19. Delaney Complex, Stow-Bolton.
20. Pontoosuc Lake, Oneta Lake, Pittsfield.
21. Leonard Pond, Agawam.
22. Lt. William's Pond, Harvard.
23. Prescott Peninsula, Quabbin Reservoir.
24. Nantucket Island ponds, Nantucket.

GENERAL METHODS

The techniques employed during this study were similar to those used by Grice and Rogers (1965). Nest boxes as described by McLaughlin and Grice (1952) were checked once a week until an incubating hen was observed, then left undisturbed for three weeks. After the three-week period had lapsed, the box was revisited and the hen captured on the nest by blocking the entrance and grabbing the hen by hand after removing the nest box cover. The hen was checked for band or web tag and banded if need be. Final clutch size was determined at this time. Since both the date the first egg was laid and the final clutch size was known, the probable date incubation started could be derived. The first check for hatching was made during the 28th day of incubation. Eggs were checked for audible and visible signs of hatching and rechecked every 24 to 48 hours thereafter, depending on hatch signs.

Ducklings were web tagged with Style 4-1005, size number 1 monel fish tags (National Band and Tag Company, Newport, Kentucky). Each tag was marked with a letter and consecutively numbered allowing individual identification of ducklings. Tags were self-piercing and applied with needle-nose pliers (Grice and Rogers 1965:7-11).

Web tagging was discontinued (except for ducklings hatched in cylinders) on all areas except Great Meadows National Wildlife Refuge in 1971 and at Great Meadows in 1974. Box checks were limited to checks every two or three weeks thereafter.

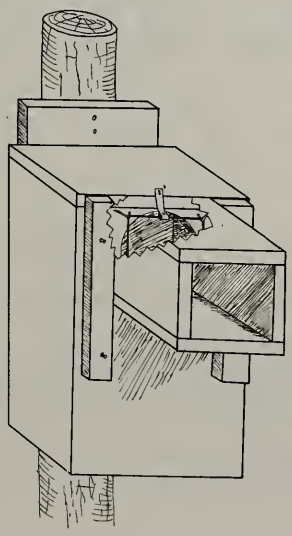
Blood smears were taken from all nesting hens and a large percentage of summer and fall-trapped birds as part of a blood parasite study conducted during 1970 and 1971. Blood was obtained by pricking the femoral vein with a disposable, sterile blood lancet. The smear was made following the technique described by Mosby *et al.* (1969) and preserved in 100 percent ethyl alcohol. Slides were marked and sent to Dr. Gordon F. Bennett of Memorial University of Newfoundland for analysis.

Summer trapping of birds for banding was achieved by rocket netting (Taber and Cowan 1969), airboat nightlighting (Cummings and Hewitt 1964) and bait trapping. Early bait traps were similar to those described by Grice and Rogers (1965). During 1970 and after, floating bait traps designed by Peter Pekkala, were used. These were made with 1 x 2 inch welded wire and consisted of a 122 by 9 x 30 cm. (48 x 36 x 12-inch) wire trap mounted on a 122 cm. (48 inch) square plywood platform. The platform was buoyed up by a sheet of polystyrene, 5 cm. (2 inches) thick. The polystyrene was edged with 1

x 2 inch wood straps and nailed in. There were two 15 x 15cm. (six by six-inch) entrances, one on each side in diagonal corners where the excess platform allowed ducks to loaf. The ducks were funneled into the trap by means of a 36 cm (14-¼ inch) deep tunnel which tapered to a 9 x 12 cm. (3-½ x 4-¾ inch) outlet. The tunnel was attached to the trap with hog rings which allowed the tunnel to lift up when a duck pushed into the trap and fall back into place once the bird was in the trap. A wire top entrance, 60 x 60cm. (2 x 2 foot) allowed removal of the ducks. The wooden portions of the trap were baited with whole corn. Traps were closed twice a week between the middle of July and the first of October.

These traps were extremely successful in capturing wood ducks. Up to 35 birds were taken at one time. On that occasion, the floor of the trap was actually awash from the weight of the birds. At first, few black ducks (*Anas rubripes*) and mallards (*A. platyrhynchos*) were captured in the traps, as they were apparently leery of entering the small entrance. However, in subsequent years, they became more aggressive and were readily captured. Division wildlife photographer, William C. Byrne, Jr, reported that mallards in a trap would often station themselves at the entrance and prevent wood ducks from entering by pecking at them.

Color marking of nesting wood ducks was accomplished by modifying the wooden tunnel predator guard with metal hooks to create a device that would automatically collar a wood duck with a rubber band to which had been attached a colored, numbered, vinyl streamer (Figure 1). The collar slipped off the hooks and around the bird's neck as it passed through the predator guard. Birds were initially reluctant to use the boxes with collars in place but most birds eventually did. During 1975 and 1976, multiple collaring attempts were made on several areas and 14 of 16 target hens were collared, deposited an egg and behaved normally afterwards (Heusmann *et al.* 1978).



NESTING HISTORIES

Great Meadows National Wildlife Refuge

A 29-year nesting history of wood duck production on the Great Meadows National Wildlife Refuge impondments is presented in Table 1. The initial six-year period was covered by Grice and Rogers (1965). By the end of their study, production had apparently leveled off after an initial dramatic increase. However, lack of recruitment of yearling hens noted in 1956 manifested itself in a production decline that began in 1959 (Grice 1962). Low levels of production prevailed through 1966 then began to decline in 1967.

Table 1

Number of Wood Duck Nest Boxes, Usage, and Production at Great Meadows National Wildlife Refuge (Marsh Impoundments)

Year	Boxes Available	Number of Nest Starts[1]	Number Successful Nests	Number of Ducklings Produced
1951	71	31	24	278
1952	72	44	38	423
1953	72	79	50	687
1954	71	95	48	572
1955	72	82	50	728
1956	125	84	63	758
1957	126	70	58	696
1958	124	71	58	692
1959	119	45	38	437
1960	99	46	36	343
1961	111	46	37	379
1962	97	43	32	322
1963	96	43	30	284[2]
1964	99	38	31	364
1965	99	35	31	385
1966	96	45	35	406
1967	95	29	22	243
1968	51 + (10)	18 (0)	15 (0)	188 (0)
1969	47 + (-)	13 (-)	13 (-)	150[3] (-)
1970	61 + (-)	6 (-)	5 (-)	44 (-)
1971	61 + (9)	7[4] + (3)	5 + (3)	50 + (32)
1972	53 + (10)	8[4] + (3)	5 + (3)	60 + (25)
1973	35 + (11)	3 + (11)	2 + (10)	25[5] + (106)
1974	33 + (10)	16 + (7)	12 + (4)	138 + (52)
1975	31 + (12)	17 + (3)	15 + (1)	167 + (12)
1976	31	12	9	106
1977	29	14	13	176
1978	25	17	14	160[6]
1979	27	9	8	115[6]

1 - Includes random nests.
2 - Does not include 126 eggs collected for DDT study.
3 - Does not include 15 eggs from Box 40 hatched by cooperator.
4 - Includes one incubating hen with no clutch.
( ) - Area 1 river box data.
5 - Includes 4 game farm ducklings.
6 - Estimate.

The 1968 spring ice flood, described earlier, greatly altered the physiography of the impoundments and took out many of the nest boxes. Although some were replaced, there were only 51 nesting sites where formerly there had been 95. Hens traditionally return to where they last nested successfully. The loss of previously-used nesting sites along with a drastic change in cover conditions may have resulted in increased dump nesting by older hens. In 1967, only three of 29 nests (10 %) were dump nests (►15 eggs) while in 1968, nine of 18 nests (50 %) were dump nests.

Great Meadows personnel erected wooden and metal nest structures on the Concord River in 1967 including an area of dense buttonbush cover on the river's flood plain immediately adjacent to the lower impoundment. In 1968, Wayne MacCallum (pers. comm.) checked boxes along a 4.4 km. stretch of river but found no evidence of usage. An incomplete check in 1970 revealed at least two nest attempts were made in river boxes. In 1971, we made a complete check of all boxes on the Concord River. Three of nine boxes in Area 1 (that portion of the river immediately adjacent to the lower impoundment) were used; seven of 20 additional boxes downriver were also used. The lack of cover on the impoundments and the abundance of it on the river flood plain apparently resulted in a shift in wood duck nesting areas. A second complete check of the river was made in 1972 after the metal nest structures were removed but additional wooden boxes erected. Three of 10 boxes in Area 1 were used while nine of 23 downstream boxes were used.

During the late winter of 1973, refuge personnel, observing the increase in river box use while impoundment box use was declining, removed a number of boxes from the impoundments and set them out along the river. That spring, 10 of 11 Area 1 boxes were used as were 19 of 29 downriver boxes. At the same time, only three boxes were used on the impoundments.

In 1974, there were seven nest starts in Area 1, but at least three of the nests were vandalized. Manpower shortages precluded a complete check of other river boxes but at least 15 were used. In 1975, only three nests were initiated in Area 1 and two were vandalized; 21 boxes were used downstream. River boxes were not checked after 1975.

While production was declining in Area 1, it began to recover on the impoundments. Hens that lost nests in river boxes renested on the impoundments which by now were recovering from the 1968 flood. Six hens that had been nest-trapped in river boxes in earlier years moved to impoundment boxes in 1974 or 1975. River boxes were not maintained in Area 1 and most wood duck production had shifted back to the impoundments by the end of the 1970s.

Surrounding Areas

Starting in 1966, three areas located near the refuge impoundments were selected for additional production studies. The purpose was to compare production on these smaller areas to that on the refuge impoundments. The three areas were the Buttrick Estate, Estabrook Pond in Concord and Greenough Estate in Carlisle. Production data for the three areas is combined and presented in Table 2.

Table 2

Number of Wood Duck Nest Boxes, Usage, and Production at Greenough's and Buttricks' Estates and Estabrook Pond

Year	Boxes Available	Number of Nest Attempts	Number of Successful Nests	Number of Ducklings Produced
1966	32	16	14	147
1967	44	13	8	87
1968	44	11	10	115
1969	40	12	12	130
1970	51	13	12	132
1971	50	12	10	96
1972	49	14	11	108
1973	46	12	10	117
1974	51	42	20	351
1975	58	31	24	262
1976	57	23	20	246
1977	54	30	21	269
1978	52	35	23	330[1]
1979	55	33	28	380[1]

[1] Estimate.

Greenough's was the largest of the three and boxes had been maintained on the area since the late 1940s. Al Winault, the estate's caretaker, maintained about 24 nest boxes and reported that 16 to 18 were used annually during the 1950's. This area produced the largest share of ducklings shown in Table 2, 47 percent of the 2,770 hatched during 1966 to 1979. During 1966, 12 nests produced 121 ducklings. Production declined until 1973 when only 25 ducklings were produced from three nest starts. Production was low during the early years at Estabrook and Buttrick's as well. There was one nest at Buttrick's in 1966, none in 1967 or 1968, then one, two, two, three, and five during the next five years. Production was slightly better at Estabrook. There were three nests in 1966, none in 1967, four in 1968 and then five, six, six, six and four during the next five years.

In 1974, the same year production increased on the Great Meadows impoundments, it jumped on all three of the surrounding areas. Duckling production went from 25 ducklings in 1973 to 142 in 1974 at Greenough's, from 50 to 72 at Buttrick's and from 42 to 135 at Estabrook. Production dropped slightly after 1974, but during the 1974 to 1979 period averaged 150 percent higher than for the 1969 to 1973 period. Duckling production would have been even higher, but an unknown predator, probably a mink (*Mustela vison*) was responsible for the loss of 16 of 30 nests at Estabrook Pond during 1977 to 1979. The animal also killed several of the incubating hens. Predation stopped after predator shields made from plastic garbage can lids were installed around the poles directly below the boxes.

Central Massachusetts Areas

In 1967, production studies were expanded to nine additional areas. Five were located in central Worcester County with a sixth area in northeastern Massachusetts just over the Worcester County line in Middlesex County. Three other areas were located in south Worcester County and in 1968, a tenth area, in Norfolk County, was added. Production results for these areas are listed in Table 3a and 3b.

Production in the northern portion of the range declined sharply after 1970 and never recovered. The decline occurred primarily in two areas. Chaffin's Pond, Holden, produced six broods totaling 57 ducklings between 1967 and 1969 but there was no further usage after that date. Two ponds on the Westboro Wildlife Management Area produced 12 broods totaling 122 ducklings between 1967 and 1970 but there was no production between 1971 and 1974. One hen nested on this area during 1975 through 1977 producing a brood each year. A third area, Spruce Pond, West Boylston, had never been very productive, having single nests only in 1968, 1973 and 1978. Ayer Game Farm, Ayer, fared slightly better, producing ducklings in 1967, 1968, 1974 and 1976 to 1979 for a total of 136 wood ducks. This area also produced several hooded mergansers (*Lophodytes cucullatus*) broods.

Table 3A

Number of Wood Duck Nest Boxes, Usage, and Production on Six Areas in Central Massachusetts*

Year	Boxes Available	Number of Nest Attempts	Number Successful Nests	Number of Ducklings Produced
1967	51	21	17	150
1968	49	18	15	144
1969	47	15	10	130
1970	54	11	10	141
1971	52	5	5	52
1972	48	5	4	49
1973	41	5	5	52
1974	49	7	6	7[illegible]
1975	58	8	8	106
1976	60	8	7	84
1977	64	9	8	83
1978	51	8	6	70[1]
1979	45	6	6	75[1]

* In the towns of Ayer, Rutland, Paxton, Holden, West Boylston and Westboro.

[1] Estimate.

The bulk of production, especially since 1971, was at Turkey Hill Brook, Paxton, and Long Pond, Rutland. These two areas provided 77 percent of the 644 ducklings produced during the 1971 to 1979 period on the six central study areas. Production at Long Pond remained stable during the 1967 to 1976 period averaging 36 ducklings annually but fell to only a single successful nest annually after that date. Production at Turkey Hill Brook increased from 16 ducklings in 1967 to 75 in 1970, then fell off to single nests of 12 and 13 young in 1973 and 1974, during the aftermath of a water drawdown between 1971 to 1973 . Five hand-reared hens were released on the area in 1975 and one nested that year. Production averaged 33 young annually for the 1975 to 1979 period.

Production on the four southern areas was substantially higher. The increase in production in 1968 as noted in Table 3b was due primarily to adding the Bristol-Blake State Reservation, Norfolk, to the list. This area produced 132 ducklings its first year and averaged 135 ducklings thereafter, ranging from a low of 98 in 1972 to a high of 200 in 1979. In 1971, six nest boxes were erected on dead, flooded timber at the Norfolk Correctional Institution, 1.7 km. (1.1 mi.) west of Bristol-Blake. The prison pond was formed by damming the headwaters of the Stop River just below where Stony Brook flowed in. A hen that nested at Bristol-Blake in 1970 brought off 12 young in a prison pond box in 1971. The hen returned in 1972 and a second unbanded bird also nested on the pond. Boxes were added and by 1979, the area was averaging 10 nests annually.

Table 3B

Number of Wood Duck Nest Boxes, Usage, and Production in Four Areas in South-Central Massachusetts*

Year	Boxes Available	Number of Nest Attempts	Number of Successful Nests	Number of Ducklings Produced
1967	35	14	12	134
1968	67	28	23	278
1969	68	31	28	309
1970	74	40	35	456
1971	79	33	29	358
1972	80	31	23	290
1973	80	32	29	365
1974	87	45	36	474
1975	81	42	32	385
1976	69	48	36	454
1977	75	48	34	448
1978	67	48	29	395[1]
1979	80	38	31	405[1]

* In the towns of Webster, Mendon, Hopedale and Norfolk

[1] Estimate.

A second important production area was Breeding Pond, Webster. Although there were six nest attempts in 1967, only two were successful and only 12 ducklings were hatched off. Production averaged 46 ducklings between 1968 and 1971 and then began to increase until 19 successful nests from 31 starts in 1977 produced 279 ducklings. The 1975 to 1979 period was characterized by high levels of box usage, dump nesting and nest abandonment, but production still averaged 223 ducklings annually. However in 1979, only eight hens nested and there were only eight nests in 1980.

On a smaller scale, Fisk Mill Street Pond in Hopedale, had four nests producing 52 ducklings in 1967 and increased to a maximum of 10 nests with 144 ducklings in 1973. Dump nesting was common and box usage high, but there was less abandonment than at Breeding Pond. Neverthless, production began to decline and by 1979 production had ceased. We could discern no reason for the decline.

Production also fell off at Nipmuc School Pond, Mendon, but the drop could be accounted for. The area started with six nests producing 63 ducklings in 1967 and averaged 74 ducklings annually for 1968 to 1971. During the fall of 1971, three of eight hens that nested on the area were reported shot during the hunting season. There were four nest starts the following spring but three were broken up by an unknown predator and two of the hens killed. The fourth successful nest was a renest and only six ducklings were hatched. There were no nests in 1973 and the area averaged only one successful nest between 1974 and 1979.

Southeastern District

Production data from other areas of the state is limited. Richard Turner, Game Manager for the Southeastern Wildlife District. provided records for the following areas: Meadow Lea Bog, Easton; Kaplousky's Bog, Duxbury; Mazzella's and Atwood's Bogs, Carver; and Great Cedar Swamp, Hanson. These areas were checked intensively between 1971 and 1975. There were a total of 36 wood duck nests in 1971 with production of 344 young. This increased steadily through 1975 when 75 nests produced 587 young. Much of the production, however, came from a single area, Meadow Lea. This area produced 31 percent of all the ducklings for the five areas during 1971 to 1975.

NESTING SITES

In 1949, a study was initiated to determine the number of natural cavities suitable for wood duck nesting in the Great Meadows area. A similar study was made in 1950 on the Burrage Swamp area in southeastern Massachusetts. The two studies showed a minimal number of natural cavities suitable for wood ducks. An intensive nest box erection program was begun and Grice and Rogers (1965) subsequently described population increases on both areas.

During the last 30 years, however, two new biological factors may have affected the number of natural cavities available. The first is the outbreak of Dutch elm disease. The disease was first reported in this country in 1930 (Whitten 1964). It did not become widespread in the Massachusetts region, however, until the late 1940s and early 1950s. The disease is still killing American elms (*Ulmus americana*) throughout the state. Allowing time for decay and cavity formation, new cavities may have become available since Grice and Rogers' (1965) study. The question of the suitability of these cavities for wood duck nests is left unanswered. Grice and Rogers (1965) found a single cavity in an elm during their study and it was utilized by a wood duck. Cavity suitability criteria were described by Grice and Rogers (1965:17).

The second factor that may have increased the number of potential cavities is an increase in the Massachusetts beaver (*Castor canadensis*) population. When beaver construct dams in wooded locations, the subsequent flooding of the area will kill the trees. Cavity formation proceeds and some cavities may be suitable for wood duck occupancy. The newly-created ponds provide new habitat and may bring existing cavity trees to within suitable distance for wood ducks.

In 1928, the first beaver colonies since the late 1700s were recorded in Massachusetts. In 1948, there were over 40 separate colonies, the majority being located in Berkshire County. Other colonies were located in Franklin, Hampshire and Middlesex Counties (Shaw 1948). The 1949-1950 census located 74 active colonies and the population was estimated at 430, up from 300 during the 1947-1948 census (Saville and Minor 1952). Beaver continued to expand their range, spreading into Hampden, Worcester and Essex Counties. Beaver located in Plymouth County were believed to be the result of a release (J. E. Cardoza, pers. comm.). A trapping season was held in 1946 but was not reopened until 1952. Since that time, fur harvest data have indicated a fluctuating but increasing population with a record harvest of 2,121 beaver during the 1979-1980 season. Division game biologist, James E. Cardoza, reports that beaver populations appeared to stabilize in Berkshire County in the late 1970s but continued to in-

Figure 3. Wood duck hen on a nest in an apple tree. (James E. Cardoza)

crease in both numbers and range in Worcester and Middlesex Counties.

In addition to the above factors, a third factor has probably increased the number of natural cavities available since Grice and Rogers' (1965) study—time. The hurricane of 1938 was one of the most destructive in history, leveling entire tracts of timber. Griscom (1949) reports that every nesting tree in the Town of Maynard was blown down. Grice and Rogers' (1965) natural cavity study was conducted a decade after the hurricane. Thirty more years have passed since then. While there have been storms since then, including a pair of hurricanes in 1954, none equalled the timber destruction that occurred in 1938. It is logical to assume that during that time span more cavities have formed than have been lost. (Figure 3)

Manmade nest structures have also been important to Massachusetts wood ducks in past years. During the winter of 1948-1949, Division personnel began making wood duck boxes and erected them in the best wood duck habitat available. At the same time, a large number of surplus ammunition boxes were converted into nesting boxes by boring a suitable entrance hole in each box. These were distributed to sportsmen's clubs and to interested individuals who agreed to place them in habitat not already covered by Division crews. By 1953, when the program ended, approximately 3,500 Division boxes and another 4,000 converted ammunition boxes had been erected (Grice and Rogers 1965:1)

Not all these boxes could be checked and maintained annually; therefore, a three-year cycle for checking individual areas was used in most of the wildlife management districts. Division personnel discovered that the average life of a nest box was about six years, and by the mid-1950s many boxes erected during the original program were badly deteriorated. Thomas Sheehan, game manager for the Northeast Wildlife District (pers. comm.), reported maintenance of boxes on many rivers normally checked in the spring was curtailed when district personnel began carrying the full workload of the Massachusetts spring trout stocking program in the mid-1950s. Previously, most of the stocking was done by game wardens.

Figure 4. A wood duck nest box equipped with a tunnel predator guard.

By the latter half of the 1950s, the number of boxes available to wood ducks had greatly declined. Griscom and Snyder (1955) reported the wood duck population as increasing with the state program of putting nest boxes in every available marsh, but declining again as the boxes deteriorated. Maintenance of boxes on areas with low wood duck usage was reduced or eliminated since there was little incentive to invest manpower on marginal areas. This resulted in a snowballing effect as statewide production dropped in the early 1960s. When production began to increase in the 1970s, many former wood duck nest box sites no longer possessed functional boxes.

In 1972, the Division published a popular article on wood ducks and hooded mergansers in MASSACHUSETTS WILDLIFE (McCallum 1972) and followed it with an offer of instructions on how to build and erect wood duck nest boxes. Since that time, the Division has distributed over 500 sets of instructions. The Division currently maintains about a thousand boxes on 185 areas. The Great Meadows National Wildlife Refuge has 106 boxes on their land (Tom Goettel, pers. comm.). The Western Massachusetts Duck Hunters Association has erected close to 300 boxes (William Borchers, pers. comm.). We believe perhaps another 1,000 boxes are maintained by private individuals or groups throughout the state. (Figure 4)

DISEASES AND PESTICIDES

In order to determine if disease was responsible for the low survival rate noted for ducklings in the 1960s, Grice (1963b) initiated tests to determine the prevalence of omphalitis and paratyphoid. Minor incidences of both diseases were reported in earlier studies. In omphalitis, there is a failure to completely absorb the yolk sac before hatching, thus providing a vulnerable site for infection. Ducklings die of salmonella bacteria infections a few days after leaving the nest. Paratyphoid disease is also caused by one of the bacteria of the salmonella group with the bacteria being transmitted to the ducklings before they hatch via the hen's ovaries. Grice found that the incidence of omphalitis and paratyphoid were minimal and neither disease was the cause of the brood mortality observed.

A third possible disease that might affect the survival of ducklings is a malaria-type protozoan, *Leucocytozoon simondi*. This organism, an avian hematozoan, or blood parasite, is carried by black flies (Simuliidae) and enters a duck's blood stream when it is bitten by an infected fly (Cook 1971). The parasite caused 20 to 80 percent mortality rates among young Canada geese in Michigan and 100 percent mortality in domestic ducks in Canada (Bennett *et al* 1974).

Grice collected blood smears from immature wood ducks in 1952. Only one of 230 birds tested was infected with *Leucocytozoon* (Her-

man *et al.* 1971). In order to determine the current level of infection, we took blood smears from waterfowl during the years 1969 to 1972. The infection rate for immature wood ducks was 11 percent (44 of 397). The rate for adults was 49 percent (139 of 282). While 14 species of waterfowl were sampled, the infection rate was highest for wood ducks (Bennett *et al.* 1974). The parasite was not as prevalent in immatures as in adults. Since young birds are more susceptible to the parasite itself or to predation and other environmental stress because they are weakened by the infection, they may have died before they were old enough to be sampled. Wood ducks also had a 94 percent infection rate for *Haemoproteus nettionis* and a 15 percent rate for *Plasmodium circumflexum*. Bennett *et al* (1974) concluded that blood parasites may be acting as a factor of population control on wood ducks in Massachusetts.

Pesticides have been indicted as contributing to the decline of several wildlife species (Stickel 1973, Reichel *et al.* 1974, Blus *et al.* 1974, Henny *et al.* 1977). During the late 1950s, project personnel had noted great decreases in both the number and kinds of aquatic insects present on the Great Meadows refuge. This was attributed to extensive insecticide spraying in the Concord area to combat mosquitos, gypsy moths and elm bark beetles.

Reichel and Addy (1968:178) found that black duck eggs from New Jersey, New York and Massachusetts contained "...appreciably higher residue of DDT and metabolites..." than did those from other states in the upper half of the Atlantic Flyway. Longcore and Stendell (1977) demonstrated that DDE, a metabolite of DDT impaired black duck productivity. Grice (1963b) checked DDT levels in Great Meadows wood duck eggs and found that 36 percent of the eggs were contaminated. The amount of residue increased from first egg to last and was higher in renests than in first nests. This implies that the source of DDT was primarily local and not acquired on the wintering grounds.

Other wood duck eggs collected by Division personnel were hatched by Jewell (1965) and the ducklings were hand reared. Jewell analyzed ducklings that died early during his project, for insecticides and found no correlation either between DDT concentrations in the ducklings or between the concentrations found in the eggs of their clutches and the mortality of the ducklings. He also found that ducklings dosed at 20 mg. DDT in corn oil per kilogram of body weight experienced no mortality but ducklings dosed at 50 mg. DDT/kg. suffered a 40 percent mortality rate under standard laboratory conditions. More important, when subjected to starvation conditions, more than 50 percent of the 20 mg. dose ducks died whereas no control birds did. This points to the impact that sublethal levels of pesticides may have on waterfowl.

In 1964, 96 wood ducks hatched by Jewell and raised on commercial rations until four to five weeks of age were released on the Great Meadows refuge. Grice (1964) recaptured both Jewell's hand-reared birds and known wild-reared wood ducks and noted stunting or retardation of the wild birds. He attributed this to a lack of protein in the wild ducklings' diet, probably due to low insect populations on Great Meadows.

To further check the effects of dietary protein on wood duck development, eggs collected from several Massachusetts areas were hatched by Johnson (1971). He raised groups of ducklings on diets of 5, 10, 15 and 20 % protein. Survival rates were 11.4, 25.7, 53.1 and 63.1 % for each respective group. Johnson (1971) also noted significantly different ($P < 0.05$) growth rates between each group of ducklings based on tarsal measurements. He observed that plummage development was retarded, with slow primary development in birds fed at lower protein levels. Such birds would take longer to attain flight stage and thus be exposed to the hazards of a flightless existence for a longer period.

The outdoor use of DDT and other organochlorine pesticides was banned in Massachusetts in 1970. This presumably led to an increase in populations of aquatic insects (though no measurements were made) and hence an increase in duckling food supply. Wood duck populations began to increase in the early 1970s and we no longer observed stunted ducklings on the Great Meadows refuge. Pesticide spraying continues with the use of organophosphates and the dangers of reducing waterfowl food supplies through the random destruction of insect population remains.

YEARLING PRODUCTIVITY

Grice and Rogers (1965) observed that some known age wood ducks were not found nesting as yearlings but did show up as two or three-year-old birds. Similar observations have been made by other researchers (E. F. Hester, R. W. Fuller, pers. comm.) and some aviculturists have reported birds that did not nest until two years old (J. Farrell, D. Risch, pers. comm.). Grice and Rogers (1965) associated this delay in nesting with an increasing population and a limited number of nest boxes. Since that early study, however, we have accumulated evidence that some yearling wood ducks do not nest regardless of nest site availability.

Heusmann (1975:503) reported that 88 female wood ducks, web-tagged between 1963 and 1972, were recaptured in subsequent years but that only 51 of these were found nesting as yearlings. The rest were not handled until their second fall or later. Fourteen were first found nesting as two-year-olds, eight as three-year-olds and 15 were recaptured during summer banding efforts or reported shot their yearling summer or later without ever having been recorded on a nest. Since band reporting rates rarely approach 100 % (Martinson 1966), the 15 hens are a minimum number. Some of 15 birds may have nested undetected away from their natal marshes; however, all but three were either trapped on their natal marsh or reported shot in the same town in which the marsh was located.

Grice and Rogers (1965:83) found that the mortality for wood ducks past their first year of life was approximately 50 percent. In Heusmann's (1975) study, 24 of 51 hens that nested as yearlings lived to nest as two year-olds. The mortality rate was 53 percent. If this rate is applied to hens found nesting as two-year-olds, then the surviving 14 two-year-olds represented a yearling population of 30 females (Table 4). The mortality rate for two-year-old females was much lower than for yearlings: 16 of the 24 two-year-old second nesters and ten of the 14 two-year-old first nesters survived to nest as three-year-olds, indicating that they were subject to a mortality factor of 31.6 percent. Thus, the eight hens found nesting for the first time as three-year-olds represented approximately 12 two-year-old hens or 25 yearlings.

When the figures for non-nesting yearlings were added to the 15 ducks recovered by trapping and hunting and to the 51 birds that did nest during their first breeding season, the total yearling hen population for the 1964 to 1973 period was projected to be a minimum of 121 birds (Table 4). The 51 yearlings nesters represented only 42 percent of the original population.

Similar findings have been reported by Clawson (1975:78) in Missouri. He found that only 47 out of 99 hens that nested on his study area did so as yearlings; 35 were first discovered as two-year-old and 17 others were not found until their third year or later.

Some of the older Massachusetts hens may have nested and escaped detection, but the chances are low. During the 1963 to 1972 period, nest boxes were checked at weekly intervals and only two of 669 incubating hens escaped handling. Since yearling wood ducks have strong homing instincts (Grice and Rogers 1965:30), it is unlikely that a bird that nested on one marsh as a yearling would move to another marsh to nest in a later year. Some hens may have nested in natural cavities as yearlings and then moved to boxes, but we believe that such moving accounted for only a small portion of the missing yearlings. Heusmann's (1975) data on clutch size supports this belief.

Table 4

Number of Wood Ducks Nesting at Each Year of Life, Eastern Massachusetts, 1963-1974

	Breeding Season		
	1	2	3
First nest as yearling	51	24	16
First nest as two-year-old	(30)[a]	14	10
First nest as three-year-old	(25)[a]	(12)[b]	8
Non-nest recoveries	15	0	0
Total yearling population	121		

[a] Estimated number of non-nesting females; a 53.0% mortality rate of yearlings assumed.

[b] Estimated number of non-nesting females; a 31.6% mortality rate of two-year-olds was assumed.

Many workers have offered evidence that yearling waterfowl lay smaller clutches than older birds, but Dane (1965), working with blue-winged teal (*Anas discors*), is one of the few to document this difference statistically. Heusmann (1975) analyzed a sample of 26 known-age wood ducks with a nesting history of two years or more. Only nests of 15 or fewer eggs were included to minimize the occurrence of dump nests (Morse and Wight 1969, Hartman 1972). The average clutch size for 26 yearlings nests was 9.8($S^2 = 5.545$). The average clutch size for 24 of these same hens found incubating normal (6 to 15 eggs) size nests as two-year-olds was 11.6 ($S^2 = 4.940$), a highly significant difference ($P < 0.01$).

If all the hens found nesting for the first time as two-year-olds had, in fact, nested undetected as yearlings, there should be no significant difference between their average clutch size and that of two-year-old hens known to be nesting for the second time. The average clutch size for a sample of 16 hens found incubating for the first time as two-year-olds (including birds banded as immatures as well as web-tagged birds) was 10.4 ($S^2 = 2.924$). This was a significantly smaller clutch size ($P < 0.10$) than for the known two-year-old, second-nest birds. The

fact that a significant difference could not be demonstrated at a higher probability level may have been due to some of the first-nest, two-year-old hens actually having nested undetected as yearlings or that they lay slightly larger clutches than yearlings because of greater physiological maturity.

In order to determine if there was any correlation between early and late-hatched wood ducks and whether such birds nested as yearlings, Heusmann (1975) separated a sample of 27 web-tagged year-old hens into three age classes: hatched on or before 15 May, hatched between 16 and 31 May, and hatched after 31 May. There was no correlation between hatching date and yearling nesting (six versus eight, 28 versus 18, and 17 versus 10, respectively). Dane (1965), working with early and late-hatched blue-winged teal, found physiological differences between the two groups of birds, but the differences were not reflected in the birds' productivity.

Several other factors may affect yearling productivity in wood ducks. Some field workers within the Division believe the abandonment rate for yearling wood ducks is higher than for older birds. When abandonment occurs before a hen is captured for banding, we cannot determine the age of the bird. However, the abandonment rate for 71 yearling nests after nest trapping the birds was 8.4 percent while it was 4.5 percent for 88 nests of known previous nesters. This may mean only that birds handled in previous years are more tolerant of the capture experience. Thus age related differences in abandonment may not necessarily reflect prehandling abandonment rates. It is likely, however, that inexperienced nesters are more easily frightened off a nest than experienced nesters.

Hatching rate is also important to productivity. Heusmann (1975) reported that the hatching rate of 59 successful yearling wood duck nests of all sizes was 90.9 percent (602 of 662 eggs). The hatching rate for 59 successful nests of birds with a previous nesting record was 87.2 percent (715 of 820 eggs). The lower hatching success for the older birds was a reflection of larger clutch sizes and agreed with findings by Morse and Wight (1969) and Heusmann (1972).

A final factor in yearling productivity among wood ducks is the subsequent survival of broods after hatching. Grice and Rogers (1965:71) compared survival to flight stage of ducklings hatched by yearling hens with that for ducklings hatched by old females. The authors demonstrated that survival of young was equivalent for both types of mothers for the same season period but that the later in the season the young were hatched, the poorer their survival. Grice and Rogers (1965:45) and Hartman (1972) also observed that yearling wood ducks nested later than adults, with the peak of yearling nesting occurring approximately one month after the adult peak. Therefore, yearling wood ducks raised fewer young to flight stage per duckling hatched than did older hens (15% versus 24%, Grice and Rogers 1965:71).

Cavity nesting species are often limited by nest site availability. This may be compensated for, however, by a higher success rate than that experienced for ground-nesting species. Since suitable cavities are limited and adult wood ducks tend to nest before yearlings (Grice and Rogers 1965), there would be less genetic selection toward first-year nesting. The common goldeneye (*Bucephala clangula*) and the Barrow's goldeneye (*B. islandica*) as well as the bufflehead (*B. albeola*), all cavity nesters, do not attain sexual maturity until two years of age and, therefore, do not nest during their first season. The hooded merganser, also a cavity nester, is believed not to reach sexual maturity until its second fall, and captive hooded mergansers have not bred until their third spring (Morse *et al.* 1969).

The combination of limited yearling nesting, smaller clutch size, and poor brood survival due to late-season hatching all limit the contribution that yearling wood ducks make to the species' annual production. The fact that some yearling wood ducks do nest whereas the yearlings of other cavity nesters do not, may be an adaptation that allows full utilization of suddenly available habitat; e.g., when a severe ice storm breaks limbs and exposes a number of heart rot cavities. Grice and Rogers (1965) and Hartman (1972) report that the first yearling wood ducks established nests about two weeks after the first adults, with the yearling nesting peak occurring a month after the adult peak. Since incubation in wood ducks lasts about 30 days, it is possible that late-nesting yearlings could use some of the same cavities utilized earlier by adults. This could increase the species' annual production, a further genetic incentive for at least some nesting efforts by yearlings.

DUMP NESTING

Dump nesting, also referred to as compound or community nesting, occurs when more than one female uses a nest site. This behavior was intensively studied in Massachusetts between 1971 and 1978 (Heusmann *et al* 1980).

Grice and Rogers (1965) arbitrarily defined a dump nest as any nest with 16 or more eggs. Morse and Wight (1969:286) checked wood duck nests to determine rates of egg deposition and found "...no nest with sixteen or more eggs to have a normal rate of egg deposition..." They also found some nests with less than 16 eggs to be dump nests based on egg deposition rates and other criteria. Hartman (1972) found dump nests varied in size from eight to 43 eggs and normal nests of up to 20 eggs. However, only 4.6 percent (four out of 87) of the normal nests checked by him contained over 15 eggs. For this study, the data on numbers of dump nests represent minimal figures and the use of the term "dump nest" refers to nests of 16 or more eggs.

Dump nesting is a common occurrence in box-using populations of wood ducks in Massachusetts. During the period 1967 to 1972, 21 percent (104 of 487) of the wood duck nests checked by waterfowl crew personnel were dump nests, with the yearly average varying from 15 percent in 1967 to 28 percent in 1969. During the period 1973 to 1977, 31 percent (141 of 456) of all nests were dump nests with a yearly variation between 20 percent (1975) and 41 percent (1977). Since only nests of 16 or more eggs were considered dump nests, the rate of dump nesting is presumably higher than the figures indicate.

Many theories have been advanced on the reasons for dump nesting. Robinson (1958) in a California study, related dump nesting to a scarcity of nest sites. We checked a pond in Concord in 1978 that had only two functional boxes; one was being used by four hens. We erected several more boxes. One of these was used the following day and nests were established in two others within three days. Dump nesting ceased in the original nest once other boxes were made available to the dumping hens. Eventually, 10 nests were established on the pond. The lack of nest sites was believed responsible for the dump nest in this situation. Normally, however, many more boxes are present on a site than are ever used, but dump nesting is still a common occurrence.

Grice and Rogers (1965) found that dump nesting was more prevalent in early than in late-season nests and attributed this to competition for nest sites. Morse and Wright (1969), in Oregon, found dump nesting to be independent of competition for sites. On the Bristol-Blake study area in Massachusetts, 15 of 28 nest boxes were used by wood ducks in 1970. In 1971, four of the first five nests were known dump nests (►15eggs) despite the availability of at least 11 other apparently acceptable boxes. Grice and Rogers (1965) suggested that an adult hen returning to nest the next year may find the box she used the previous year taken over by another female but still attempts to use it, thus creating a dump nest. In 1971, however, two of the four dump nests were in boxes not used in 1970. Eventually, many of the other boxes on the pond were used. This does not mean that a hen competing for a box she had used previously may not be involved in creating a dump nest. Hen 735-57685 nested in Box 17 at Breeding Pond, Webster, in 1974, 1975 and 1976. She abandoned the nest in 1976 after being nest-trapped and renested successfully in Box 6. In 1977, Bellville observed her laying again in Box 17. A second hen also laid in the box and both hens were color-marked (see GENERAL METHODS). The hen that finally incubated the clutch of 22 eggs was not color-marked but was the same hen that used the box in 1976 after Hen 735-57685's abandoned clutch was removed.

Grice and Rogers (1965) suggested that some yearling wood ducks may pass through a parasitic stage during which they lay eggs in the nests of other wood ducks before establishing nests of their own. Hartman (1972) nest-trapped wood ducks that were inspecting boxes but captured no known yearlings until after the peak period of dump nesting. Clawson (1975:79) reported that only one of 24 known yearlings initiated a nest during the first nesting peak. In this study, we were not dealing with a population of known age birds. However, we nest-trapped extensively before and during the years of this study and prior to 1978 only five of 260 hens on successful nests escaped handling. There were also some late-season abandonments prior to handling but the chances of capturing an unbanded hen that had nested previously were remote. We observed that five of 12 (41 percent) hens that were confirmed as dumping eggs in nests eventually incubated by other hens were unbanded and probably first-time nesters. They may have been two or three-year-old hens nesting for the first time (Clawson 1975:78, Heusmann 1975). The other hens ranged up to eight years in age. Our conclusions agree with Clawson's (1975) that all ages of wood ducks are involved in dump nesting

Hartman (1972) observed that wood ducks appear to prefer nesting in boxes with eggs over unoccupied boxes. Clawson *et al.* (1979:353) reported that 96 percent of the wood duck eggs dumped in their observation area were in boxes that already contained eggs. In order to determine if the prior presence of eggs affected box usage, we placed dummy eggs in a random sample of nest boxes. Ten areas in eastern and central Massachusetts were used for this study. Boxes on each area were classified as either having been used at least once during the previous two years or as having no recent use. Boxes were reclassified each year of the three-year study which ran from 1972 to 1974.

Dummy eggs were created by hard boiling small, white chicken eggs. A mixture of commercial food coloring dyes was used to simulate wood duck egg color. Only eggs of typical wood duck shape were used. Three eggs were placed in half of the randomly-selected recent use (RU) and no recent use (NRU) boxes. All eggs were in place by mid-March, approximately two weeks before the first wood duck nests are initiated in eastern Massachusetts.

Table 5a presents the results of wood duck nest initiation. The deposition of one or more eggs was considered a nest start. A total of 67.9 percent of the control RU boxes were utilized as was 68.1 percent of the dummy egg boxes. In the NRU boxes, utilization ran 57.7 percent for the control boxes and 51.0 percent for dummy egg boxes. There was no significant difference (Chi square $P > 0.05$) between nest initiation in control boxes and boxes with dummy eggs.

Table 5a

Nest Initiation by Wood Ducks in Control and Dummy Egg Nest Boxes on Ten Massachusetts Study Areas

	Recent Use Boxes				No Recent Use Boxes			
	Controls		Dummy Nests		Controls		Dummy Nests	
Year	Number Boxes	Number Nest Starts	Number Boxes	Number Nest Starts	Number Boxes	Number Nest Starts	Number Boxes	Number Nest Starts
1972	20	12	17	9	15	5	13	5
1973	21	9	22	12	15	6	15	4
1974	37	32	30	26	22	19	21	16
Totals	78	53	69	47	52	30	49	25
Percent Usage	67.9		68.1		57.7		51.0	

Table 5b

Nest Attendance by Wood Ducks in Control and Dummy Egg Boxes

	Boxes Used Within the Past Two Years				Boxes Not Used Within the Past Two Years			
	Controls		Dummy Egg Boxes		Controls		Dummy Egg Boxes	
Year	Nest Starts	Nests Incubated	Nest Starts	Nests Incubated	Nest Starts	Nests Incubated	Nest Starts	Nests Incubated
1972	12	11	9	5	5	4	5	3
1973	9	8	12	12	6	6	4	3
1974	32	25	26	17	19	16	16	10
Total	53	44	47	25	30	26	25	16
Nest Attendance (%)	83		72		87		64	

Table 5b compares nest attendance between control and dummy egg boxes. Nest attendance was defined as any sign that a hen had incubated the clutch. Nest attendance of RU control boxes was 83.0 percent versus 72.3 percent for dummy egg boxes. The attendance rate for NRU control boxes was 86.7 percent and 64.0 percent for the NRU dummy egg boxes. The records for the study areas from previous years as well as from nonstudy areas in current years indicate an expected nest attendance rate of 86.0 percent. A Chi square test for goodness of fit indicates no significant difference ($P > 0.05$) between the expected and observed attendance rates for either RU or NRU control boxes and no significant difference in RU dummy egg nest attendance. A significant difference can be demonstrated at the 0.1 level for lower nest attendance of NRU dummy egg nests than would be expected.

In order to determine if past nesting experience was involved in whether or not a hen used nests with eggs, incubating hens were recorded as being known previous nesters (previously banded on a nest) or probable first nesters (unbanded). The ratio of new birds to old is presented in Table 6. While the first two years' data appears to indicate that new birds nested in dummy egg boxes at twice the rate of older birds, this did not hold for the third year of the study when the wood duck nesting population increased greatly.

Table 6

Comparison of Wood Duck Usage, by Age, of Control and Dummy Egg Boxes in Ten Massachusetts Study Areas

	Control Box		Dummy Egg Box	
Year	Number New Hens	Number Old Hens	Number New Hens	Number Old Hens
1972	7	6	4	2
1973	6	6	8	4
1974	25	15	16	12
Totals	38	27	28	18
Percent	58	42	61	39

The results of the dummy egg study indicate that the presence of eggs in a box does not influence dump nesting. This agrees with findings by Weller (1959) on redheads (*Aythya americana*). He created artificial dump nests utilizing three redhead eggs but none were used by redheads. His field observations led him to conclude that parasitic redheads followed other hens to their nests and then dumped eggs, usually after the other hen left.

Our observations indicate wood ducks have a strong decoying effect on one another. The normal state of affairs was to have from two to as many as five pairs of ducks around a single box. Frequently, when one pair moved to another box, one or more other pairs would follow. While watching boxes at the Greenough estate, Carlisle, on 10 April 1977, Heusmann observed hen 775-36455 and her mate fly to Box 10. She was joined by a second and third pair of birds. Hen'455 entered Box 10,a dump nest, immediately came out and flew to nearby Box X-30. She was immediately followed by hen 805-75517 and her mate. Hen '455 entered unused Box X-30 and laid. Hen '517 attempted to approach the box several times but was repulsed by '455's mate. She then flew a short distance to unused Box 7 where the third pair of birds, still on Box 10, flew also. The two pairs both investigated Box 10. After hen '455 left Box X-30, Heusmann confirmed that she had initiated a nest. Hen '517 then flew to Box X-30,entered it and laid. During later checks, we discovered an unknown third hen was also laying in Box X-30. Hen '517 was observed on X-30 on 17 April and was thought to be incubating but finally incubated a clutch in Box 15 on 1 May. Hen '455 incubated the clutch in X-30.

Jones and Leopold (1967) associated dump nesting with wood duck population density. We believe population density is involved in dump nesting. During the years 1970 to 1972,there was an average of six nests at Breeding Pond with 22 available boxes. Dump nests comprised 21 percent of the nesting efforts. The area averaged 14 nests annually during 1973 to 1975, with 40 percent dump nests, and 26 nests during 1976 to 1978 with 52 percent of the nests being dump nests. (The number of available boxes was increased to 26 in 1974 but only 22 were functional by 1978.) At first it would appear that dump nesting increased since the population of nesting hens increased and the birds began competing for boxes. However, during the periods studied, most dumping activities were completed by 1 May with only 40 to 60 percent of the boxes having been used. For example, at the Greenough estate, in 1978 one nesting cylinder had eight eggs added to it in a single day. A total of 13 eggs were laid that day and during the

same week, the number of eggs laid in nesting structures varied from 12 to 14 even though only five of 22 nesting structures were being used. By the end of the season, 15 different hens had established nests in 15 boxes.

We believe that dump nesting is caused by a variety of factors and conditions including scarcity of nest sites and competition for sites, but that imitation and visual stimulation is the primary reason for dump nesting. Clawson (1975:115) determined that nest box density was greater than natural cavity density, that boxes are conspicuous and that predation was reduced in areas where artificial nesting structures were used. He believed that net effect of these three factors was to present potential dump-nesting females with both the stimuli and opportunity to dump eggs. Our findings largely support his conclusions.

Researchers have expressed conflicting opinions on the role of dump nesting in wood duck populations. Jones and Leopold (1967) concluded that it was detrimental while Grice and Rogers (1965) and Morse and Wight (1969) indicated that dump nesting contributed to the population. Before the effects of dump nesting can be assessed, several factors must be considered. These include rates of abandonment, hatchability of eggs, the effects of egg dumping on normal clutch sizes, nesting activities of hens after egg dumping and survival of young after hatching.

Jones and Leopold (1967), dealing with a rapidly expanding wood duck population and a scarcity of nest sites, found that less than half of the dump nests checked produced ducklings, whereas approximately two-thirds of the normal nests resulted in duckling production. Data on abandonment rates for Great Meadows are presented in Table 7. The period 1952 to 1954 represents a rapidly expanding population while the population during 1964 to 1966 was relatively stable. When totals for the two periods were considered, abandonment rates for dump nests were lower than for normal nests. When a normal nest hen abandoned a nest, the clutch was lost, but when a dump nest hen abandoned a nest, there was a possiblility that a second hen might incubate the clutch.

Table 7

Abandonment Rates of Wood Duck Nests on the Great Meadows National Wildlife Refuge

	1952	1953	1954	Total	1964	1965	1966	Total
Normal Nest								
Number of nests	27	30	35	92	31	21	34	86
Number abandoned	1	14	18	33	4	1	4	9
Percentage abandoned	3.7	46.7	51.4	35.7	12.9	4.8	11.8	10.6
Dump Nest								
Number of nests	18	44	55	117	6	10	6	22
Number abandoned	4	10	24	38	1	0	1	2
Percentage abandoned	22.2	22.7	43.6	32.5	16.7	0.0	16.7	7.7

Clawson *et al.* (1979) reported similar findings for Missouri. Since abandonment of dump nests was not a critical factor during our study, it was excluded from further consideration.

A second point considered when comparing production of dump nests and normal nests was hatchability. If no more ducklings hatched from each of the larger nests than from each of the normal nests, the importance of survival of broods from dump nests would be minimal. Table 8 presents data on the rates of hatch of normal and dump nests for the periods 1952 to 1954 and 1964 to 1966. During both periods, the average hatch success for dump nests was lower than for normal nests. There was a correlation between the size of clutch and the size of hatch in both normal and dump nests (Heusmann 1972). This agrees with the findings of Morse and Wight (1969).

Table 8

Wood Duck Nest Data for Great Meadows National Wildlife Refuge
1952-1954 and 1964-1966

	1952-1954		1964-1966	
	Dump Nest	Normal Nest	Dump Nest	Normal Nest
Number of nests	79	57	20	89
Number of eggs	1,652	610	382	918
Number hatched	1,232	501	330	840
Average clutch	20.9	10.7	19.1	11.8
Average number hatched	15.6	8.8	16.5	10.7
Percentage hatched	74.6	82.1	86.4	91.5

Wood ducks are indeterminate layers. Dane (1973) suggested that among such birds, some stimulus such as number of eggs or surface area of eggs leads to specific clutch size. Welty (1975) adds that the feel of enough eggs against the bird's belly may stimulate the pituitary to suppress ovulation and initiate incubation behavior. If this happens to hens subjected to dump nesting, such birds may lay fewer eggs than they would normally. During one phase of our studies we created artificial dump nests by adding six game farm wood duck eggs to each of 13 normal but incomplete clutches of six to eight wild wood duck eggs to determine how the additional eggs affected the size of the clutches laid by wild hens. We then compared the number of eggs laid by hens that incubated the 13 artificial dump nests with the number laid by hens incubating 13 normal wild nests. All nests were located in the same geographic area. The average clutch size of natural nests was 11.7 while the number of eggs laid by hens in artificial dump nests averaged 10.4. This was not a significant difference ($S^2 = 0.721$, $P \blacktriangleright 0.05$).

The creation of artificial dump nests by depositing six eggs in a nest in a single day does not simulate a natural dump nest. Normally, one or two additional eggs may be added to a clutch over several days before one hen begins incubation. As a result, the sudden influx of eggs in a single day after a clutch is half completed may result in a different effect than the addition of one or two eggs a day over several days beginning early in incubation. Clawson (1975:94), however, found that hens subject to natural dump nesting also laid an average of 1.0 fewer eggs than hens in non-dump nests. While this again could not be demonstrated to be a significant difference (P ► .05), the data suggest that females may slightly reduce their clutch size when subjected to dump nesting by other hens.

Heusmann (1972) observed that the full impact of dump nesting in wood duck populations could not be evaluated until it was determined if hens that dumped eggs in the nests of other wood ducks later established nests of their own. In order to accomplish this, it was necessary to determine which hens were dumping eggs and to mark these hens so that they could be identified if found nesting later in the season. One means of accomplishing this was by color-marking birds. However, we found that wood ducks captured in nest boxes during laying or early incubation would desert their clutches. It was necessary, therefore, to develop an automatic means of color-marking wood ducks that would not affect their subsequent behavior. Richard Burrell, an assistant game biologist with the Division, came up with the idea of automatically marking nesting females by modifying existing tunnel predator guards (see GENERAL METHODS). With the development of this technique, we were able to begin a study to determine if hens that dumped eggs eventually established their own nests.

Seven areas where dump nesting was a common occurrence were selected for early-morning observations during the period 1975 to 1978. Nest checks were made at three to five-day intervals. When a clutch was discovered, it was rechecked one to three days later to ascertain the rate of egg deposition. If the rate exceeded one egg per day, the clutch was considered the result of dump nesting. Egg colors and shapes were also noted. Normally,it is difficult to distinguish one egg from another, but we have found some wood ducks lay eggs that vary enough from the norm so as to allow identification even when mixed in with those of other hens. For example,some hens may lay especially dark eggs or eggs that are unusually round or perhaps football shaped.

When a dump nest was identified, an automatic collaring device was installed on the box (Heusmann *et al.* 1978). All eggs present in the clutch were marked so that additional eggs would be identifiable. An observer arrived in the area at first light the following morning, positioned himself so he could not be seen by birds using the box or boxes being watched and observed proceedings by means of 7 x 35 binoculars and/or a 20-power spotting scope. When a hen entered a

box, she was collared with a rubber band to which was attached a colored vinyl streamer bearing a numbered metal tag. After the hen left the box, the observer checked the box to determine if she had laid. If she had, he then marked the egg, placed another collar on the device, and repeated the process on the next hen. On some areas, marking guards were placed on all boxes in order to mark inspecting hens. This allowed observers to follow the movements of individual hens without disturbing them.

Occasionally, a marking frame (Heusmann *et al.* 1978:432) was used to mark females as they exited from a box if they had not been previously collared. No attempt was made to mark birds already collared but some hens were collared inadvertently several times. All boxes on the study areas and on surrounding areas were checked at regular intervals and attempts made to nest-trap all incubating hens. No attempt was made to gather a complete nesting history of any female. We were concerned only with marking a maximum number of dumping hens to confirm whether such birds eventually incubated nests of their own.

Sixteen hens were confirmed as laying at least one egg in boxes that were eventually incubated by other hens; 12 later incubated clutches of their own. Eight other hens were believed to be dump nesters based on marking evidence and field observations. All eight established their own nests. In seven additional instances, hens that were confirmed as laying in boxes that contained dump nests which were later abandoned were found incubating clutches in other boxes. In such situations, we did not know if the hen was a dumping bird or the initiator of the abandoned nest. Finally, five hens were collared while inspecting boxes; two later established nests.

We observed a variety of dump nesting behavior during this study. The following case histories describe some of the types of behavior recorded.

A total of 12 wood duck nests were started at Fisk Mill Pond, Hopedale, in 1975; three were random clutches of one, one and three eggs. The other nine nests were incubated to term. Four of the nine nests were dump nests caused by two different hens. Hen 595-26528 was an eight-year-old female hatched in Box 4 in 1967 that had nests in Box 6 in 1968,Box 3 in 1970 and Box 6,again, in 1972 and 1974. There was no record of her nesting in 1969,1971, or 1973. In 1975, this hen was collared in Box 3,observed in Box 8 and seen entering and laying in Box 4 before finally establishing her own nest in Box 7. We believe she deposited a total of seven eggs in Box 3; three eggs in Box 8 and at least one egg in Box 4 before incubating nine eggs in Box 7. All laying took place between 8 April and 11 May. Box 7 was apparently the only box she laid in that did not have eggs prior to her usage. There was no dump nesting on the pond in 1976 when this hen incubated a clutch of 13 eggs in Box 7. She was not recorded in 1977 or 1978.

Hen 735-57676 had nested in Box 5 on the same pond in 1973 and Box 2 in 1974. In 1975, she was collared in Box 11 where we believe she laid at least five eggs during an eight-day period. she was also confirmed as laying in Box 4 when she, Hen 595-26528, and a third hen that incubated the clutch, all laid in the box. Hen '676 successfully incubated a clutch of 13 eggs in Box 5.

We discovered that frequently a hen added only a few eggs to a box used by another bird before establishing a nest of her own. A typical situation was encountered at Fisk Mill Pond during 1977. Eight eggs had been added to Box 9 in five days. The day before observations began, a new nest was started in Box 8. On the morning that Burrell observed the area, hen 775-36474 was collared in Box 9, laid and subsequently incubated the clutch. She had also nested in the box in 1976. Hen 775-36440 used Box 8, laying a second egg. When the two eggs were compared to the nine in Box 9, it was apparent that hen '440 had laid three of the nine eggs. We have found that wood ducks generally increase the amount of time spent in a box as their clutch increases. They may spend 10 to 20 minutes in the box at the onset of egg laying and increase that time to two or three hours by the fifth or sixth egg when they begin to add down. Apparently hen '440 began sharing Box 9 with hen '474 about the time '474 had laid a second egg. By the time '474 had been laying for five days, she was spending three hours on the box, forcing hen '440 to use the next nearest box, 8, which she had used in 1976. We do not know why '440 did not use box 8 initially.

An occasional hen refused to enter a box with a set collar. During 1976, there were two successful wood duck nests at Long Pond, Rutland. There was also one incomplete hooded merganser nest. A wood duck (unidentified but suspected to have been dumping hen 775-36149 based on egg measurements, shape and color) deposited two eggs in the merganser nest. Another egg, perhaps from this same hen, was found in the water under Box 8, a dump nest box. The dumping hen, '149, was never collared but she had been banded in Box 1 in 1974 and used box 2 in 1975.

On the day of observation, hen '149 made repeated attempts to enter Box 8 where a set collar was in place but never entered and finally laid in Box 12, a previously unused box. When the boxes were checked the next day, one additional egg was laid in both boxes 8 and 12. The third day, only the hen from Box 8 showed up to lay. The following day collars were placed on all the boxes on the pond. Hen '149 made repeated attempts to enter unused Box 5, and then Box 12, but shied away from the collars. When the Box 8 hen arrived and entered that box, taking the collar with her, '149 swam over from Box 12, entered the box and deposited an egg despite the presence of the original hen. On the fifth day, the Box 8 bird arrived first and entered the box. Hen

'149 arrived while the Box 8 hen was laying. Collars were placed on all boxes except 8 and 12. Hen '149, however, paid attention only to Box 8. She peered through a gap between the entrance hole and the lid and could apparently see the Box 8 hen on the nest. She checked several times and finally entered Box 8 an hour and 15 minutes after arriving on the pond. At this point, Heusmann attempted to affix a frame equipped with a collar on the outside of the box to mark hen '149 as she exited, but she flushed and flew to the opposite side of the pond where she deposited an egg on a stump. By the next observation period, three days later, '149 was regularly laying in Box 12 and incubated a clutch of 12 eggs. We believe she also deposited two in Box 8. The hen that incubated in Box 8 had been collared four times during the observation period. In 1977, hen '149 was collared in Box 8 and confirmed as dumping an egg in that box, but incubated a clutch of 10 eggs in Box 1. The clutch of 12 eggs in Box 8 was incubated but abandoned before the hen could be nest trapped.

We have found that hens may not incubate nests they initiate. Hen 805-75693 was collared on 12 April 1978 in Box 13 at the Bristol-Blake State Reservation, Norfolk. Box 13 was a dump nest being used by at least three hens. She did not lay on the day she was collared in that box but, instead, initiated a clutch in unused Box 20. She was observed laying a second egg in 20 the following day. Egg deposition rates in 20 were normal until 16 April when two eggs were added. The nest in 20 was incubated, but the pole and box fell over before the hen could be handled. Hen '693, however, was found a few days later incubating in Box 9, a nest that had been initiated on 13 April by an unknown hen. This was also recorded as a dump nest with four eggs added in two days. Hen '693 was unbanded and had no nesting history. She apparently began nesting in Box 9 a few days after initiating the nest in Box 20.

An example of a dumping hen that was not found incubating a nest is afforded by a hen that was observed in Box 6 at the Greenough Estate, Carlisle, in 1978. The hen was already in the box, a dump nest being used by three hens, when we checked the pond shortly before dawn. The hen had been collared around the rump instead of the neck. Since we were concerned that she would lose the collar, a second collar was put on a marking frame outside the box. The disturbance caused her to leave the box and she was loosely collared around the neck. She managed to pull the second collar off. A second hen entered, laid and left the box before another collar could be put on. A third hen was collared and laid an egg in the box. She eventually incubated in the box a week later. The rump-collared bird hadn't laid and she flew to Box 12. This box had three eggs in it, the third one having been laid earlier that morning. The hen entered the box and laid. No other eggs were added to the clutch and it was abandoned. Two days later, the rump-collared hen was collared around the neck while inspecting unused Box 4. She then entered Box 1, an unused box in which we had placed nine eggs

removed from a nearby nesting cylinder which was being used by several hens. She laid in Box 1. No further eggs were added thereafter. The bird was next observed six days later when she flushed off the pond, still bearing the rump and neck collars. She was not recorded thereafter. Later in the season, two hens that nested in cylinders avoided all efforts to nest trap them and there were also two abandoned nests in boxes. The rump-collared hen may have been involved in one of the four nests for which no hens were captured.

The final factor that must be considered before dump nesting can be construed as either beneficial or detrimental to a population of wood ducks is the survival of young after hatching. Heusmann (1972) selected two periods for study at the Great Meadows National Wildlife Refuge.

The first, 1952 through 1954, represented rapidly expanding wood duck population. The number of ducklings produced on the Great Meadows refuge increased from less than 300 in 1951 to more than 750 in 1956. During the period from 1952 through 1954, the number of nest attempts increased from 44 to 95, with 72, 72, and 71, respectively, nest boxes available each of the three years. A dramatic decrease in the population occurred in 1959.

The second period, from 1964 through 1966, was selected as representative of a stable population, although evidence based on recruitment of web-tagged hens indicated that the population actually may have been declining (Grice 1966). During this period, the number of nest attempts fluctuated from 38 in 1964, 35 in 1965, 45 in 1966 and then declined to six by 1970. There were 99, 99, and 96 nest boxes available in 1964, 1965 and 1966, respectively.

Data was collected from 237 wood duck nests during the six breeding seasons of 1952 through 1954 and 1964 through 1966. Ducklings were retrapped using bait traps during the summer and fall.

McGilvrey (1969) observed wood duck broods and found that over 90 percent of the preflight mortalities occurred during the first two weeks after hatching. He felt that Class II ducklings provided a reliable estimate of production to flight stage. Therefore, in considering trapped ducklings, only birds of this development or higher were included in the data.

Table 9

Recapture Rates for all Successful Dump and Normal Wood Duck Nests on the Great Meadows National Wildlife Refuge, 1952-54 and 1964-66

	Dump	Normal	Dump	Normal	Dump	Normal	Dump	Normal
	1952		1953		1954		Total	
Number of nests	14	24	34	16	31	17	79	57
Number of ducks tagged	190	200	514	100	417	137	1,121	437
Number of ducks recaptured	41	83	167	23	87	15	295	121
Percentage recaptured	21.5	41.5	32.5	23.0	20.9	10.9	26.3	27.7
Number of recaptured ducklings per nest	3.4	3.8	5.2	2.0	3.1	0.9	4.1	2.4
	1964		1965		1966		Total	
Number of nests	5	27	10	21	5	30	20	73
Number of ducks tagged	81	236	140	175	84	315	305	726
Number of ducks recaptured	25	56	44	40	12	80	81	176
Percentage recaptured	30.8	23.7	31.4	22.9	14.3	25.4	26.5	24.3
Number of recaptured ducklings per nest	5.0	2.1	4.4	2.4	2.4	2.8	4.4	2.6

The results of the two trapping periods are presented in Table 9. There were more normal nests than dump nests with no recaptures (21 versus 14 for 1952-54 and 25 versus 2 for 1964-66). This resulted in similar recapture rates for both types of nests during the two study periods. During the 1950s, 26.3 percent of all web-tagged ducklings from dump nests were recaptured compared with 27.7 percent of ducklings from normal nests. During the mid-1960s, these percentages from dump and normal nests were 26.5 and 24.3, respectively.

There is no evidence to indicate that smaller wood duck broods are more prone to leave an area than larger broods. If the assumption is made that ducklings from both dump nests and normal nests are equally available for trapping, then survival rates of wood ducks to flight stage were similar for both types of nests. Therefore, dump nests produced more flying birds per nest than normal nests.

Similar findings were reported by Clawson (1975:65) for Missouri using a slightly different approach. He examined data on bait trapping and hunting season direct recoveries of wood ducks web-tagged as day-old birds. Clawson (1975) found that the percentage of young web-tagged in normal and dump nests was 28 and 72 percent respectively, while 24 and 76 percent of the recoveries were from normal and dump nests, respectively.

Both the Great Meadows Refuge and the Duck Creek Wildlife Management Area (Clawson's Missouri study area) are large areas connected to other wetlands. Most wood duck broods apparently stay on the refuges. We have observed, however, that on many small areas where wood ducks typically nest in Massachusetts, hens lead their broods off the area soon after hatching. It would seem that a hen with a large number of ducklings would lose a greater percentage of her brood on such overland travels than would a hen with a smaller brood. Unfortunately, fall trapping data for such areas is limited precisely because of wood duck movements. Therefore, survival-to-flight-stage data for 1,307 web-tagged normal-size nest ducklings and 686 dump-nest ducklings was based on limited fall trapping, birds reported shot, and returning hens. By combining this data, we found that 5.0% of dump-nest ducklings were traced to flight stage versus 6.3% of normal-nest ducklings. When sample means are compared using a t-test, no significant difference was demonstrated ($P > 0.05$).

To determine if the size of a brood may affect recovery rates, the same data were broken down into four brood size classes (Table 10).

Table 10

Wood Duck Recovery Rates Based on Brood Size
(Massachusetts 1967-1971)

Brood Size	Ducklings Tagged	Number Recovered	Percent Recovered
3- 8	217	16	7.4
9-12	831	57	6.9
13-17	677	34	5.0
18-24	268	10	3.7
Totals	1,993	117	

A downward trend in survival rates as brood size increases is evident but the small sample size precludes adequate statistical analysis. Futher research is required to determine if the survival of young from dump nests is different on sites where hens travel with their broods between nesting and rearing areas than on large wetlands where all rearing requirements are met.

In summary, (1) hens subjected to dump nesting do not lay significantly smaller clutches than in the absence of dump nesting, (2) abandonment rates for dump nests are no higher than for normal nests, (3) most hens that dump nest later establish their own clutches, (4) survival of young from dump nests is, on large wetlands at least, proportionate to that for normal nests. It appears, then, that dump nesting is beneficial to wood duck populations.

Clawson *et al* (1979) believe that dump nesting is a normal behavior for wood ducks that use natural cavities as well as for those using boxes. In a species where nesting is restricted to specific nest sites, it is important that optimal use be made of all available sites. Since dump nesting leads to larger broods and survival of young is high, dump nesting allows more birds to reach the point of reproductive capability, assuring that the population will remain at maximum levels.

STARLINGS AND WOOD DUCKS

The starling (*Sturnis vulgaris*) was first successfully introduced into North America in New York's Central Park in 1890 and 1891. Eighty birds were released each year (Cooke 1928). Since then, the starling

has extended its range over most of the United States and southern Canada. Like the wood duck, the starling is a cavity nester and when wood duck boxes were erected in Massachusetts, starlings also began to use them (Grice and Rogers 1965).

The male starling customarily selects a nest site and tries to attract a female to it. Frequently, he removes materials from the cavity when not actively trying to attract a female (Kessel 1957). When a wood duck box is selected as a nest site, the male will remove shavings from the box, sometimes nearly emptying it. This appears especially true if he does not find a mate. We have checked boxes in which starlings have never established a nest but which are devoid of shavings. Such boxes are not suitable for wood duck use.

If a starling does find a mate, both sexes begin bringing coarse grasses into the box, building a bulky nest that sometimes fills the structure to the entrance hole. The nesting materials usually render the box unusable for wood ducks. Occasionally, starlings will begin using a box in which a wood duck is laying. While starlings are normally leisurely nest builders, as egg laying time approaches, they become industrious and can build a nest in two or three days (Kessel 1957). In such cases, they bury the wood duck eggs causing the wood duck to abandon the box. We have found, in general, that if a wood duck is more than halfway through her clutch when starlings attempt to take over the box, she may effectively compete with the starlings, disrupting their nest-building attempts during her daily visits and keeping the starlings away as she prolongs her nest attentiveness. However, if she has not firmly established herself at the nest site, the starlings will take over the box, burying her incomplete clutch.

Less frequently, starlings may be using a box when a wood duck begins to use it. If the nest is a modest affair and the starling is about to or has begun egg laying, the wood duck may lay in the starling's nest and use the nesting material to cover her eggs, destroying the starling nest in the process. Since the starlings have ceased their nest construction activities, the wood duck is in a position to complete her clutch without having it buried under additional starling nesting materials. Such turnabouts, however, are rare since the period of time between nest construction and incubation for starlings is much shorter than that for wood ducks.

Starling competition for nest boxes accelerated in the early 1960s. Grice and Rogers (1965) reported that starlings clearly preferred to nest in boxes equipped with the wooden tunnel predator guards which had been developed to eliminate raccoon predation (McLaughlin and Grice 1952). Starling competition nearly eliminated wood duck populations on several Massachusetts areas.

Starlings in Massachusetts customarily begin nesting about two weeks later than wood ducks. Since the peak of yearling wood duck nesting occurs approximately a month after the peak of adult nesting (Grice and Rogers 1965), the primary focus of starling competition is directed to inexperienced yearling hens.

During 1967 to 1973, we removed all the starling nests we encountered in wood duck nest boxes every seven to ten days between 1 April and 4 July when we checked the boxes for duck nests on ten sites in eastern Massachusetts. The results are presented in Figure 5 (Heusmann and Bellville 1978).

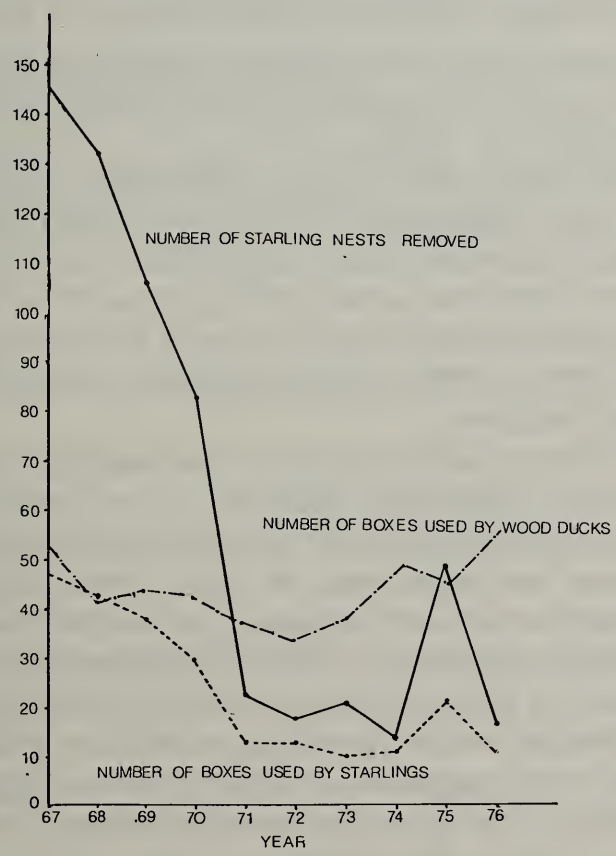


Figure 5. The number of starling nests removed from wood duck nest boxes and the number of boxes used by wood ducks and starlings (1967-1976).

Starlings used 47 boxes on seven sites in 1967 and 146 nests were removed. Nesting stages varied from nearly completed nests to completed clutches being incubated. Eight sites had starling nests in 1968 and all ten sites were used in 1969. The first results of the starling nest removal program were noted in 1970 on a pond in Holden, Massachusetts. Starlings used three boxes on the pond in 1967, two in 1968, one in 1969 and did not nest in any box thereafter. Starlings nested on six sites in 1971, four in 1972 and in 1973 only three sites had starlings; 21 nests were removed from ten boxes in 1973.

During 1974 to 1976, starling nests were removed when encountered, but checks were infrequent. As a result a few broods were successfully fledged. Nests were started on six areas in 1974 and on seven in 1975, but only four of these areas were used both years. The same four areas were the only ones used by starlings in 1976. The minor increase in nests removed in 1975 (Figure 5) is due to one site where boxes were checked every three to four days during May. As a result, 22 partially completed nests were removed from this area alone. (Heusmann and Bellville 1978).

Kessel (1957) states that starlings suffer a 50 percent annual mortality rate and that it takes about six years for the members from any single year's hatch to shrink to an insignificant portion of the population. If we assume that the actual starling population fell somewhere between the number of boxes used and nests thrown out, it is apparent that the major portion of the starling population was eliminated after four years of nest removal.

There was no numerical evidence that starling nest removal increased wood duck production since as many ducks used boxes in 1967 as in 1976. Duck production remained unchanged on four sites, increased on three and decreased on three. Other factors, however, also influenced production and we believe production would have been lower had we not greatly reduced starling competition.

Nest removal is a time-consuming method of starling control. As a result, former Division waterfowl biologist, Warren Blandin, initiated a study to determine the feasibility of using a horizontal nesting cylinder that proved effective in deterring nesting starlings at the Patuxent Wildlife Research Center (McGilvrey and Uhler 1971). The cylinders were made from 61 cm (2-foot) lengths of 30 cm (12-inch) diameter galvanized hot air ducts. The cylinders had wooden ends of 2.5 cm (one-inch) unplaned pine, completely closed at the back and with a 10 x 26 cm (4 by 11 inch) semicircular opening in the front. Each cylinder was erected on an angle iron which was equipped with a 61 or 91 cm (2 or 3-foot) length of aluminum downspout sleeve to act as a predator guard (Figure 6).

Figure 6. A starlingproof wood duck nesting cylinder with aluminum downspout predator guard. The cross braces at bottom will hinder sinkage in soft-bottomed ponds. (Karen Fogarty).

A study was conducted between 1970 and 1975 on a total of 23 areas across the state, utilizing a total of 84 cylinders. Wooden boxes were also present on all areas and starling nests were removed from these when encountered. The results of this study were reported on by Heusmann *et al.* (1977). Table 11 is from that report.

Table 11

Wood Duck Usage of Nest Structures on 17 Massachusetts Wetlands

Year	Structure	Number	Number Used	Percent Usage	Number of Nests	Percent of Attempts
1970	Cylinders	36	6	16.7	5	83.3
	Boxes	189	80	42.3	57	71.3
1971	Cylinders	40	9	22.5	8	88.9
	Boxes	166	60	36.1	51	85.0
1972	Cylinders	43	13	30.2	12	92.3
	Boxes	163	73	44.8	59	80.8
1973	Cylinders	48	17	35.4	13	76.5
	Boxes	174	89	51.1	67	75.3
1974	Cylinders	63	27	42.8	16	59.3
	Boxes	209	121	57.9	96	79.3
1975	Cylinders	67	22	32.8	15	68.2
	Boxes	207	114	55.1	84	73.7
Totals	Cylinders	297	94	31.6	69	73.4
	Boxes	1,108	537	48.5	414	77.1

Five areas had no wood duck nests recorded in either wooden boxes or in metal cylinders; two other areas had only a single wood duck nest recorded in a wooden box during the six-year study period. All seven areas were excluded from the table. Cylinder use averaged 32 percent for the six years, increasing from 17 percent to a maximum of 43 percent in 1974. It fell off to 33 percent in 1975. Use of wooden boxes by ducks averaged 48 percent during the study, fluctuating from 36 percent in 1971 to 58 percent in 1974.

The total wood duck population during the period increased by a minimum of 83 percent (65 hens handled in 1970 versus 119 in 1974). Wood duck use of all nesting structures increased from 38 percent to 54 percent, but cylinder use increased by 26 percent while box use increased by only 16 percent. Cylinder usage increased from six attempts on three areas in 1970 to 27 attempts on eight areas in 1974.

Although the study ended in 1975, wood ducks were observed using cylinders on two new areas in 1976 and began using cylinders for the first time in the western part of the state in 1977. That year, 15 cylinder areas scattered throughout the state were checked and there were six cylinders used on four of the areas. There were 34 cylinders still functional on 12 of the areas in 1978 and 13 cylinders were used on seven areas. While the use figures are lower than reported for the 1970 to 1975 study, it should be pointed out that none of the areas checked during 1977 or 1978 were in the Southeast District where, in 1975, cylinder use was 63 percent. At Meadow Lea in Easton, 13 of 16 cylinders were used in 1975.

During all of our field checks, we never discovered any attempts by starlings to use cylinders, and from that point of view cylinders were 100% effective. However, we also observed that, in general, wood ducks clearly preferred wooden boxes to the metal cylinders. Box use was higher than use of cylinders and while only three hens out of 84 (4 %) switched to cylinders after having successfully nested on a box the previous year, six hens out of 15 (40 %) switched from cylinders to boxes (Heusmann *et al.* 1977).

We also encountered problems with sinking. Many Massachusetts ponds are soft-bottomed and a 4.5 m (15-ft.) length of angle iron of which 2 m (6.5 ft.) was above water level, would sink to below water level in three to five years. We also encountered problems with vandalism. Cylinders seemed to be especially attractive targets for sharpshooters. Finally, wood ducks flushed much more readily from cylinders than they did from boxes, probably because of the improved visibility afforded birds in the horizontal cylinders. This resulted in a higher abandonment rate than that experienced for hens nesting in wooden boxes.

As a result of these drawbacks, we experimented with a means of reducing starling competition by equipping wooden boxes with lids fitted with skylights. McGilvrey and Uhler (1971) believed that starlings did not use the cylinders they designed because of the increased amount of light let in. Game Manager Peter Pekkala developed several styles of lids with differing skylight dimensions using Filon 180 (Filon Division of Stron Corporation, Hawthorne, California), an opaque fiberglass product that passes 82 to 89 percent of full sunlight. These were tested for starling acceptance in 1974. The styles least acceptable to starlings were further tested in 1975 for both starling and wood duck acceptance. By 1976, we were down to a single style lid, one with a 51 x 133mm central skylight.

Skylight lids were put on every other box on areas where starling nesting was intensive, but wood duck nesting was limited. These areas included Cusky pond, New Braintree; Sam Kator's and the Sutton System Ponds, Sutton; Hayden and Easterbrook Ponds, Douglas; East Bolton Site, Bolton; Fletchers Pond, Stow; Pontoosuc and Onota Lakes, Pittsfield; and Leonard Pond, Agawam (See Figure 2)

Starlings constructed nests in 12 of 30 boxes (40 %) equipped with light lids and in 18 of 23 boxes (78 %) equipped with regular solid lids. The lower use rate for light lid equipped boxes was highly significant ($P < 0.01$ Chi square test of independence). This difference was even more pronounced on a regional basis. Eight of 11 light lid boxes on four areas in the western half of Massachusetts were used by starlings compared to five of nine boxes with control lid boxes. However, on seven eastern Massachusetts areas,only three of 17 light lid boxes were used by starlings versus 12 out of 13 control lid boxes. The reason for this difference may be reflected in a difference in starling population pressures between the two regions.

Since the light lids were 2.5 times longer than they were wide, we checked to determine if the direction of the long axis in relation to the sun affected usage. Boxes were divided into two groups--those with skylight whose long axis ran basically north-south, and those where the long axis ran primarily east-west. Of nine starling nests where measurements were taken, four were in boxes with skylights running north-south and five in boxes where the skylights ran east-west. Of 11 boxes with no usage, four ran north-south, three east-west and four were border line cases. We concluded that the direction of the long axis to sun had no effect on starling use of skylight-equipped boxes.

We also put skylight lids out on areas of moderate wood duck use to determine how acceptable they were to wood ducks. The areas selected for testing were Estabrook Pond, Concord; Norfolk Prison Pond and Bristol Blake State Reservation, Norfolk; Lt. Williams Pond, Harvard; and Leonard Pond, Agawam. Boxes were divided into two categories--those used the previous year by wood ducks and those that

were not. Every other box in each category received a light lid. Wood ducks initiated nests in 17 of 28 skylight lid boxes (61 %) and 21 of 30 control lid boxes (70%). This is not a significant difference (P►0.10). Thirteen (77%) of the nests intitiated in light lid boxes were successfully incubated to term as were 16 (76%) of the nests in control lid boxes.

Since wood ducks frequently return to the same box to nest in subsequent years, we checked to see what ducks used what boxes in 1975 and 1976. Of the 14 hens with 1975 breeding records, six returned to the boxes they used that year, three despite the presence of light lids in 1976 versus control lids in 1975. In some instances, boxes used in 1975 were not available in 1976. In only one instance did a hen possibly switch boxes because of a light lid, but since another hen switched boxes when both had control lids, the presence of the light lid cannot be confirmed as the sole reason for the switch.

Six of the 16 light lid boxes were used by previously banded (hence adult) hens. The other nests involved unbanded birds and, therefore, were probably hens nesting for the first time.

Light lids put out in 1976 were left on for further evaluation in 1977. Due to a variety of factors, only four of 10 areas used for starling evaluation in 1976 were still available in 1977. Nine of 10 (90%) boxes with solid lids were used by starlings and four of seven (57%) light lid boxes were used. Use in 1976 in the same geographic area was 12 of 13 (92%) and three of 17 (18%) respectively. While the 1977 sample size is too small for valid statistical testing, the data implies that aged skylight lids are more acceptable to starlings than new lids.

Lids with 95 x 95mm opaque skylights were also tested for starling acceptance in 1977 (Figure 7). Starlings normally construct their nests in a dark corner of a box. Since the Filon material scatters light, the square opening in the lid resulted in the floor of the box being evenly lit throughout, unlike the rectangular opening in which the back of the box was darker than directly under the skylight. Light lids were placed on all 10 boxes at Delaney Pond in Stow. All the boxes had been used by starlings the previous year when solid lids were in place. Only two of 10 boxes were used by starlings in 1977 although one box was used twice. All three nests were thrown out when discovered. One wood duck also nested in a light lid box.

The 95 x 95mm light lids were also placed out on three other areas where starlings and wood ducks compete for nests: Norfolk Pond, Norfolk; Leonard Pond, Agawam; and Ayer Game Farm Pond, Ayer. At Norfolk, the 51 x 133mm lids used on six boxes in 1976 were replaced by 95 x 95mm lids, and placed instead on two boxes that had solid lids that year plus three new boxes. Solid lids were placed on three old boxes and one new one. Wood ducks used five of six boxes with 95 x 95mm skylights and successfully incubated four clutches. They used four of the five boxes with 51 x 133mm skylights but none of the nests were incubated. They successfully used all four of the control lid boxes. Four of the five boxes used first were control boxes. Starlings removed shavings and added some nesting material to one box with a 51 ⁴ 133mm skylight but never firmly established a nest.

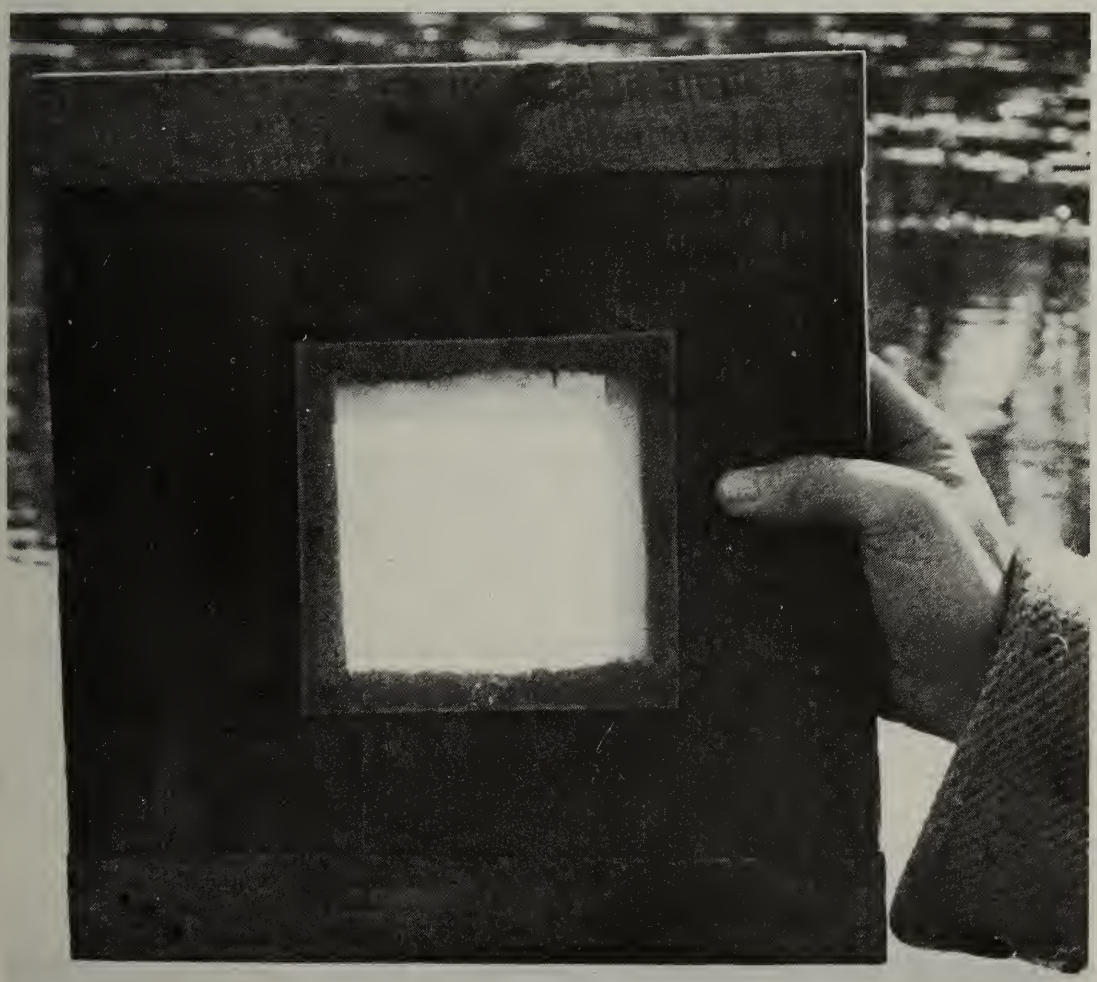


Figure 7. Skylight lid used in starling control experiment.

At Leonard Pond, the 31 x 155mm covers from 1976 were replaced with 95 x 95mm covers. There were four boxes with skylights and five with control lids. Wood ducks nested in two boxes with control lids. The three control boxes not used by wood ducks were used repeatedly by starlings. A total of 10 nests were thrown out during the four checks made on this area. There was no starling or wood duck use of the light lid boxes.

The third area, Ayer Game Farm Pond, had three boxes equipped with 95 x 95mm light lids, two with 51 x 133mm skylights and one control lid. The control lid was successfully used by a wood duck as were two of the 95 x 95mm lids. The remaining 95 x 95mm box was used by a starling. The nest was thrown out. The box was then used successfully by a hooded merganser. One of the 51 x 133mm skylight boxes was used by a starling and the other was unused.

In 1978 boxes formerly equipped with 51 x 133mm skylights or with solid control lids were refitted with slightly larger 100 x 100mm skylights on eight study areas. A total of 45 boxes were involved (Table 12). All eight areas had a history of heavy starling usage. Pre-skylight breeding records were available only for the first four areas in the table. The year before any type of skylights were used, starlings used 24 of 29 boxes (83 %) and ducks used 11 (38%). Starling nests were thrown out when encountered making boxes available to nesting waterfowl. Ten of the 11 boxes used by wood ducks were on one area--Norfolk Prison--where there were 13 nest starts in 10 boxes, nine of which were successful. However, there were six nests started by ducks in boxes only after the starling nests were removed. Had the nests not been removed, it is doubtful that the ducks could have used the boxes. The remaining four areas were not checked the summer prior to putting on skylights, but winter checks indicated near 100 percent starling use.

Table 12

Wildlife Usage of Wood Duck Boxes Equipped with 100 x 100mm Skylights on Eight Study Areas in Eastern and Central Massachusetts

Pond	No. of Boxes	No. Used by Starlings	No. Used by Waterfowl
Ayer Game Farm, Ayer	7	0	1 wood duck; 1 hooded merganser; same box; successful; 1 wood duck unsuccessful due to predator.
Delaney Site, Stow	7	0	2 wood ducks successful
East Bolton Site, Bolton	3	0	1 wood duck successful
Norfolk Prison, Norfolk	14	0	8 wood ducks successful
Sutton System, Sutton	4	2	1 wood duck unsuccessful
Sam Kators, Sutton	2	0	0
Hayden Pond, Dudley	4	1	1 wood duck successful
Cusky's Pond, New Braintree	4	1	0
Totals	45	4	7 successful; 1 unsuccess

During 1978, wood ducks established nests in 16 of the 45 boxes while a hooded merganser used one box for a 38 percent use rate. Starlings nested in only four boxes for a nine percent use rate. The data indicate no significant increase in duck use ($P > 0.05$) but a highly significant decline in starling use ($P < 0.01$). Evaluating the effects of light lids on wood duck production is hampered by the prior practice of removing starling nests which, as we have previously indicated, reduces starling populations and by the fact that we kept increasing the dimensions of the skylights over several years.

In addition to the areas in Table 12, three areas in eastern Massachusetts utilized a combination of 100 x 100mm light lids and solid control lids. A total of 10 light lid boxes had 20 percent wood duck use and no starling use, while nine control boxes had 55 percent wood duck use and 34 percent starling use. The small sample size precludes statistical analysis.

During the 1976 segment of this study, a great disparity in starling use of light-lid boxes was noted between the eastern and western portions of the state. As a result, the number of study areas in the western portion of the state was increased from three to eight. A total of 31 control boxes and 39 100 x 100mm skylight boxes were checked. Ducks used two of the light-lid boxes (5%) and 11 (35%) of the control

boxes, while starlings used 13 (33%) of the light-lid boxes and four (13%) of the control boxes. The difference in starling use with the two types of boxes was not significant (P►.05) but ducks used significantly fewer light-lid boxes than control boxes (P◄.05). The reluctance of starlings to use skylight boxes in eastern areas of the state but their ready acceptance of these same boxes in western sectors remains a puzzle. One explanation may be that several of the western study areas are beaver ponds where standing timber provides more shade, making the skylights less effective. Starlings, however, also used light-lid boxes on open marshes similar to those in the eastern part of the state.

It appears the value of light lids may be restricted to areas in eastern Massachusetts where heavy starling use prevents the wood duck's use of boxes. Wood duck acceptance of light lids in eastern study areas indicates that birds will adapt to the brighter boxes when the transition is gradual.

We intend to increase the number of cylinders in western Massachusetts to combat starling competition and rely on skylights in the eastern portion of the state.

HARVEST AND MIGRATION

The wood duck ranks third in the bag of Massachusetts waterfowlers, following the black duck and mallard. In recent years, woodies have comprised about nine percent of the total waterfowl harvest. In a state where most duck hunting is done on the coast, 82 percent of the wood duck harvest occurs inland and few birds are taken along coastal waters. The wood duck increases in importance as one moves westward across the state and is the most frequently harvested species in Berkshire County. A highly-preferred game species, the wood duck was ranked the Number 1 choice of inland gunners even through it ranked third in the bag. Even on the coast, waterfowlers ranked it among their top choices despite its being one of the least frequently harvested birds (Heusmann and Blandin 1974).

The wood duck is especially important early in the season. During the 1975 to 1977 hunting seasons when Massachusetts had a split season, opening in mid-October and running for 18 days and then reopening before Thanksgiving and running through Christmas, 86 percent of the wood duck harvest occurred during the first 10 days of the season. Only two percent of the harvest was taken during the second 32-day segment.

A history of wood duck harvests for Massachusetts since 1961 is presented in Figure 8. Only one wood duck was allowed in the bag prior to 1969 when the bag limit was increased to two birds daily. Low waterfowl populations of all waterfowl across the continent during the early 1960's resulted in the setting of restrictive bags and this, in turn,

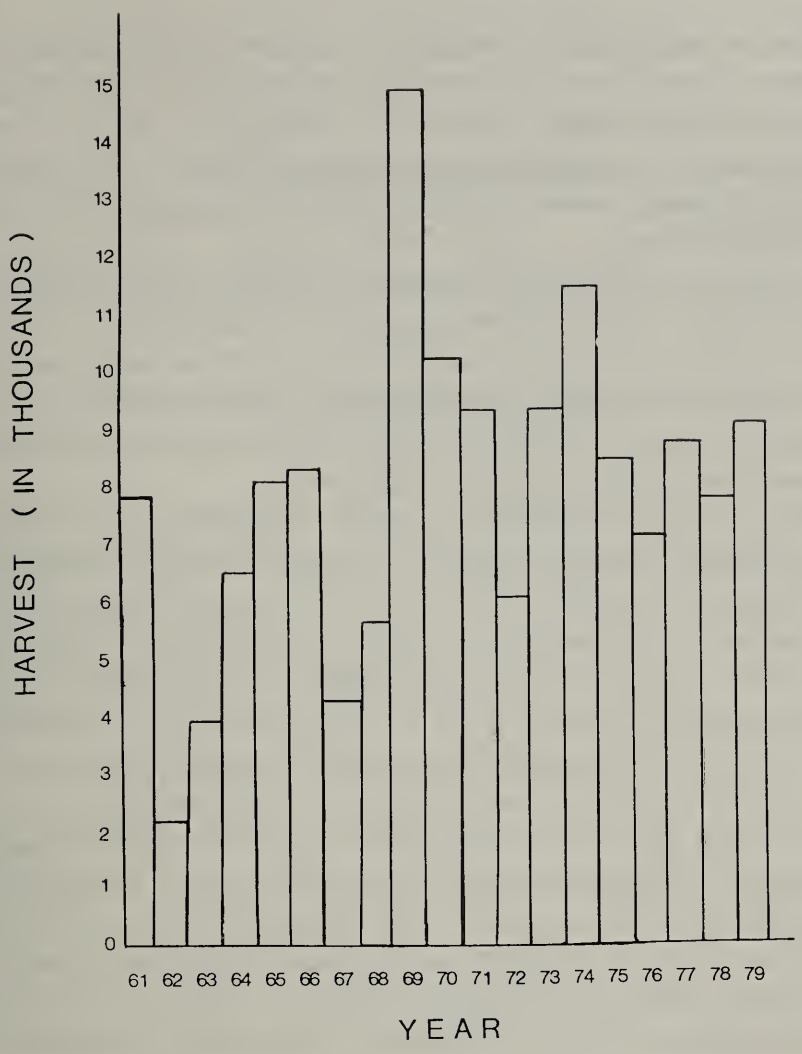


Figure 8. Massachusetts wood duck harvest, 1961-1979.

resulted in low numbers of duck hunters. During the 1961 to 1963 seasons, an average of only 12,000 sportsmen hunted waterfowl in Massachusetts. As waterfowl production increased, restrictions were relaxed and the number of duck hunters increased. Surveys indicate that 18,500 to 22,500 sportsmen currently hunt waterfowl in Massachusetts annually.

The peak harvest in 1969 (Figure 8) occurred when the increased bag limit coincided with a straight 50-day season. The straight season allowed wood ducks to be hunted until the last birds had migrated south. There was also an increase in hunters afield over previous years. While the number of hunters remained up in subsequent years, we reverted back to a split season in 1970 with only 15 days in the first segment (17 to 31 October) and the second segment not opening until 22 November after most wood ducks had migrated south.

During the years 1971 to 1973, we experimented with a zoned waterfowl season. It involved 40 or 45-day straight seasons in both a narrow coastal zone and the remaining, broad inland zone. The inland zone opened on 20 October allowing harvest during all but the earliest

part of the wood duck's fall migration, but the coastal zone never opened before mid-November, effectively eliminating 10 to 15 percent of the total wood duck harvest. Between 1974 and 1978, Massachusetts had a split season with an 18-day first segment opening in mid-October and a 32-day segment beginning the Wednesday before Thanksgiving.

In 1979, the state experimented with a three-segment season, 10-20 October, 2-24 November and 20 December-10 January. The season's weather was extremely unusual with snowfall up to seven inches in some central parts of the state on opening day, but then conditions were unusually mild into January. As a result, some wood ducks were harvested during all three segments.

During the period 1962 to 1968, Massachusetts retained a one wood duck daily bag restriction while other states allowed two wood ducks. During this period, 47.1% of all wood duck hunting season recoveries were from within the state (Table 13). In 1969, we doubled the bag limit to two birds but our share of the harvest increased less than three percent to 50% of all hunting season recoveries (Table 13). This indicated that a second wood duck in the bag is an uncommon occurrence for the bulk of Massachusetts waterfowlers.

In order to get some idea of the source of Massachusetts' wood duck harvest, we examined band recovery records for the New England states and New Brunswick. We restricted our survey to direct recoveries in order to determine the most recent source of the birds. We discovered that we accounted for only 2.2% of New Brunswick's direct recoveries, 2.3% of Maine's and 0.5% of Vermont's. There were no direct recoveries from New Hampshire's limited bandings (Table 14). A review of band recovery data for Ontario and New York-banded birds indicated practically none of those birds and very few Quebec birds are taken in Massachusetts. The data, therefore, imply that most of the wood ducks harvested in Massachusetts are raised within the state.

In contrast, the contribution that Massachusetts and the other northeastern areas make to the southern states' harvest is pronounced. Each New England state accounts for about half its recoveries. In Massachusetts' case, North and South Carolina account for 27.4 % of our direct recoveries while Georgia and Florida add another 9.2 %. The Maine southern states harvest is less concentrated with only 17.7 % of the recoveries occurring in the Carolinas and 9.8 % in Georgia and Florida. New Brunswick harvests 59 % of its birds and perhaps as a result, only 11.8 % are recovered in the Carolinas with another 8.9 % in Georgia and Florida. Vermont's data show a 13.8 % recovery in North and South Carolina with 8.1 % south of there. However, almost 9 % of Vermont's recoveries occur in Canada and almost 4 % occur in the Mississippi Flyway (Table 14).

Grice and Rogers (1965) believed that Massachusetts wood ducks drifted southward in a leisurely fashion along the Atlantic coastal plains, beginning their migration early enough to escape harsh weather changes. They also reported some late-summer wandering. Stewart (1977a, 1977b) demonstrated a radial dispersal of wood ducks prior to southward migration and reported that Vermont-banded wood ducks started their migration in early to mid-November, moving southward with the advancing season along a strip of land containing

Table 13

Comparison of Massachusetts' Share of Wood Duck Harvest, 1962-1968 vs. 1969-1978

	Direct		Indirect		Total	
1962-1968*	Number	Percent	Number	Percent	Number	Percent
Massachusetts	89	59	26	28	115	47
Other Areas	63	41	66	72	129	53
Total	152	100	92	100	244	100
1969-1978**						
Massachusetts	110	58	50	39	160	50
Other Areas	80	42	79	61	159	50
Total	190	100	129	100	319	100

* Massachusetts allowed one wood duck per day in bag.
** Massachusetts allowed two wood ducks per day in bag.

swampy habitat. These observations, however, are based on hunter-shot birds and, therefore, reflect hunting season dates in the various states rather than migration dates. Waterfowl seasons in general, begin in early to mid-October in the northeastern states, late October to mid-November in the mid-Atlantic states and mid to late November in the southern states. Consequently, birds are not reported in the mid-Atlantic or southern states until the season opens and banded birds are subject to harvest.

In reviewing recovery data from Massachusetts' wood ducks (Table 14) we see that while over 50 percent of the direct recoveries are in state, only 1.5 percent are recovered in Connecticut and Rhode Island despite the states' having similar waterfowl season dates. In fact, the first sizable harvest of Massachusetts wood ducks does not occur until they reach New Jersey, a state where the duck season opens about two weeks after Massachusetts' does. A similar trend is apparent for Vermont; half the harvest occurs in state, with practically no birds taken in southern New England. The bulk of wood duck ban-

Table 14

Distribution of Direct Wood Duck Band Recoveries, 1949-1979

Banding Location	Total Recoveries	Percent of Recoveries																	
		Canada	ME	NH	VT	MA	CT-RI	NY	PA	NJ	MD	DE	VA	WV	NC	SC	GA	FL	Miss. Fly.
New Brunswick	178	59.6*	1.7	2.2	0.0	2.2	2.2	1.7	0.0	2.8	0.0	1.1	3.9	0.0	5.6	6.2	3.9	5.6	1.7
Maine	790	1.3	50.6	1.8	0.1	2.3	1.4	214	1.9	4.2	1.5	1.3	2.3	0.0	9.4	8.3	5.3	4.5	2.1
New Hampshire	39	0.0	5.1	46.1	2.6	0.0	0.0	7.7	2.6	5.1	0.0	0.0	0.0	0.0	10.3	10.3	5.1	5.1	0.0
Vermont	1,793	8.9	0.3	0.3	50.4	0.5	0.6	4.7	2.8	2.3	1.0	0.4	1.8	0.1	6.4	7.4	4.4	3.7	3.9
Massachusetts	458	0.2	0.0	0.2	0.2	50.6	1.5	0.2	0.4	4.1	0.6	0.6	1.7	0.0	13.1	14.3	6.6	2.6	0.2
Connecticut-Rhode Island	91	0.0	0.0	0.0	0.0	1.1	22.0	2.2	1.1	1.1	1.1	1.1	2.2	0.0	16.5	25.3	11.0	10.0	5.5

* 59.0 in New Brunswick

ding in Vermont has been in the Lake Champlain region and these birds may travel down the Hudson River Valley by-passing southern New England but we also note no southern New England recoveries of New Hampshire birds and limited recoveries here of birds banded in Maine and New Brunswick (Table 14). The counter to that argument would be that these areas open their waterfowl seasons one or two weeks before the Massachusetts-Connecticut-Rhode Island seasons and that the wood ducks pass through southern New England before the hunting seasons here open.

One might also argue that since some late summer wandering of wood ducks occurs, the September-banded Massachusetts wood ducks actually hatched in northern states and were already migrating south when we trapped and banded them. If this were true we would expect some of these birds to be recovered back north in later years. However, the only Massachusetts-banded birds recovered north of the state have been a few males that had probably paired with northern-reared females and followed them north to the females' natal area.

The data in Table 14 suggest to us that rather than migrating slowly south, wood ducks remain in the general geographic area of where they spent the summer until hunting pressure or a severe freeze causes them to abandon their familiar haunts and fly several hundred kilometers south where they settle into favorable habitat until hunting pressure or weather again push them south. Thus, most Massachusetts wood ducks would bypass Connecticut and the Long Island area and land in New Jersey's wooded swamps. Later, they leave that region, skipping over the Chesapeake area, to land in Virginia or North Carolina (Figure 9). Similarly, northern-reared wood ducks would skip over Massachusetts on their way to the mid-Atlantic region.

Wood ducks are capable of sustained flights as demonstrated by a couple of immature New York males. One banded in New York on 27 September was in North Carolina on 1 October, and a second bird banded 30 August was in Florida by 2 September (U.S. Fish and Wildlife Service Bird Banding records). Despite the delay of hunting seasons in most southern states until late November, the wood duck subcommittee of the Atlantic Waterfowl Council observed that 4.7 percent of band recoveries from Northeastern Unit birds taken in the Southeastern Unit were reported prior to 15 October. This indicates at least some movements of birds early in the season. A more thorough analysis of wood duck migration patterns awaits the outcome of a biological tagging study being conducted as of this writing by the Florida Freshwater Fish and Game Commission and an early season liberalized bag experiment for southeastern states by the U.S. Fish and Wildlife Service.

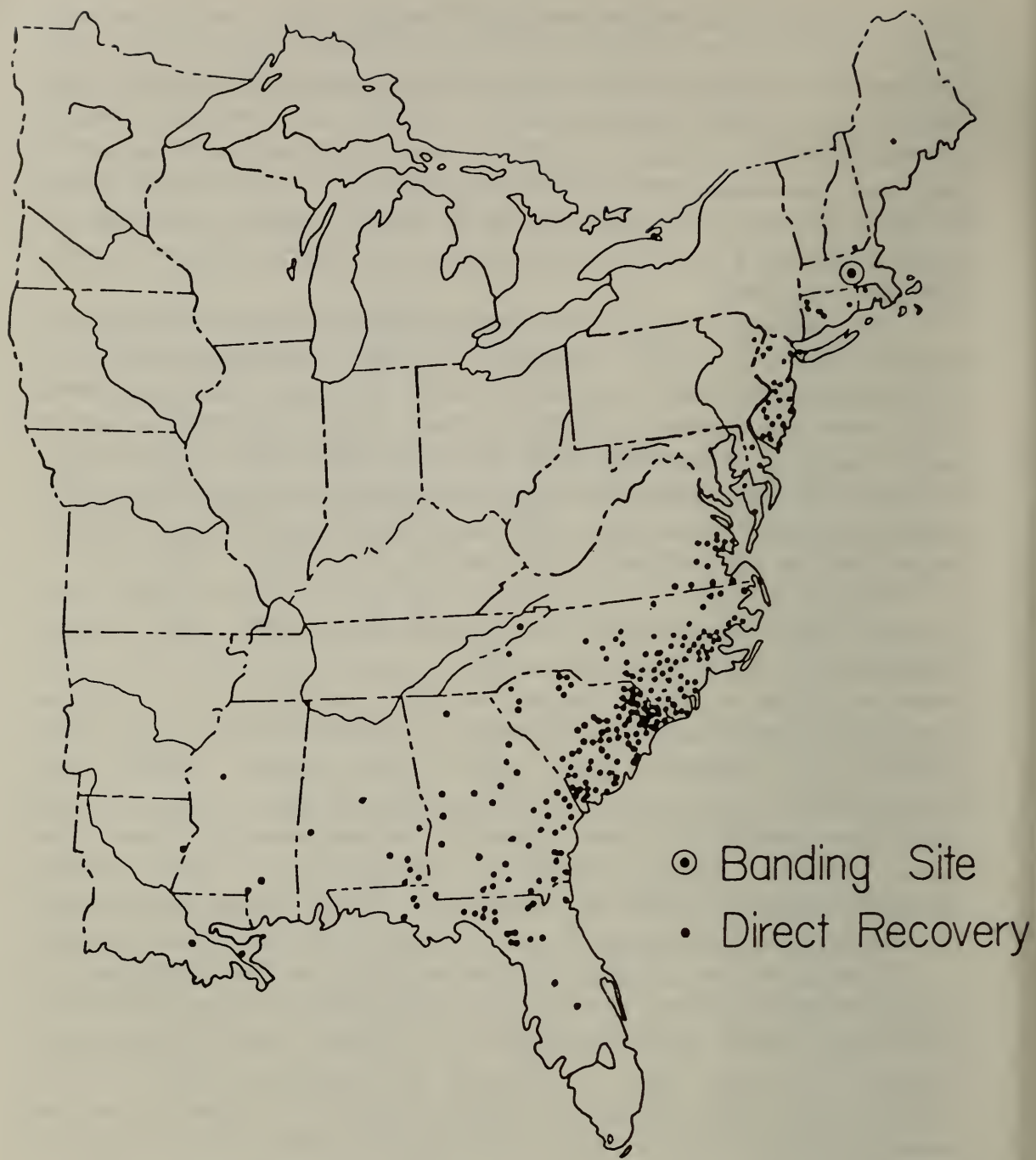


Figure 9. Direct recoveries of Massachusetts-banded wood ducks.

HAND-REARED WOOD DUCKS

The Massachusetts Division of Fisheries and Wildlife has not embarked on a large-scale wood duck propagation program since the early 1920's. Hand-reared birds, however, have been released in conjunction with other research projects. Ninety-six ducklings used in Jewell's (1965) DDT research were four to five weeks of age when released on the Great Meadows National Wildlife Refuge in 1964. Twenty-six were subsequently traced to flight stage; six of these were reported shot the following hunting season and two hens were found nesting on the refuge in 1966.

We gave Al Winault, caretaker at the Greenough Estate, eggs from abandoned nests which he artificially incubated. In 1968, he released 14 immature birds at Greenough's and we released four others at Bristol Blake. There were no returns of nesting females, although one hen was shot that fall in South Carolina and a second female was killed in New Hampshire during the 1972 hunting season.

We began a limited propagation program in 1972 in conjunction with a black duck rearing project. Six hens and four drake wood ducks were wild-trapped during the fall of 1971 and held overwinter in the black duck pen at the Ayer Game Farm. Eggs from this stock were artificially incubated in 1972 and 22 wood ducks reared to flight stage. These birds were kept for breeding purposes. Eggs collected in 1973 from the captive flock were used to create the artificial dump nests described in "Dump Nesting." Only eight wood ducks were raised by artificial incubation. All were kept to replace other breeders. In 1974, 135 eggs were collected and incubated but hatching success was low and duckling mortality high. Only eight incubator-reared birds survived to flight stage. The adult wood ducks were allowed to renest and hatch off their own young, rearing them in with the breeding black ducks and wood ducks. Eight nesting hens raised over 55 ducklings to flight stage.

In 1975, game farm production of wood ducks was almost eliminated due to raccoon (*Procyon lotor*) predation. Birds were allowed to establish and incubate their own clutches in boxes in the pen. Raccoons broke into the pen; two hens were killed, five nests broken up and three other hens abandoned clutches due to molestation. Not more than two dozen wood ducks hatched that year survived to flight stage.

The first release of wood ducks occurred in April 1975 when 24 adult birds (12 males, 12 females) were released on two beaver ponds in the 35,200-ha (88,000 acres) Quabbin Reservation located 105 km (63 miles) west of Boston. A number of black ducks were released at the same time and game farm feed hoppers set up on the release

ponds. Wood duck nest boxes and black duck nesting cylinders were present on the release ponds as well as on several surrounding ponds. The release was made on 4 April, about the time the first wood duck eggs were being laid at Ayer.

There were three random nests of one to three eggs and two successful nests on the Quabbin ponds. One of the successful nests was in a black duck nesting cylinder. There were also two abandoned nests; one contained a mixed clutch of five hooded mergansers and 10 wood duck eggs. The other clutch of seven eggs was abandoned after we nest-trapped the hen. Nests were started on a total of five ponds.

In 1976, the hen that nested successfully on a pond called Pond 4 in 1975, again nested successfully and a second unbanded bird also nested there. Since this was the first unbanded hen to nest in a Quabbin box in five years, we believe it was the progeny of a released hen. A second hand-reared bird successfully incubated a clutch of 16 wood duck and four hooded merganser eggs. She had not been recorded nesting in 1975. In 1977, this bird nested on the east side of Quabbin, 11 km (6.6 miles) from her release site. Two other nests by wood ducks in 1976 were unsuccessful and the hens never nest-trapped. A male from the 1975 release was shot the fall of 1975 in the nearby town of Orange and a second male was shot in South Carolina in November 1977.

We also made a release of five female and three male adult wood ducks at Turkey Hill Brook in Paxton in the spring of 1975. One female nested successfully that spring on the pond. None of the five hens were found nesting in boxes in 1976 but two unbanded birds used boxes and a second 1975-released hen was caught during late summer nightlighting operations along with a brood. One of the three released males was captured during nightlighting operations in 1977.

A total of 97 immature wood ducks were released on the Quabbin in August and September of 1977 including 68 birds raised by David Risch of Foxboro. Only a single nest of two random eggs was found during the 1978 checks and the only hunter recoveries were of one male taken in the vicinity of Quabbin during the 1977 hunting season and a second male shot in South Carolina in January 1980.

The propagation project was terminated in 1978 when pump failure at the game farm caused the pool to dry up. Raccoons subsequently broke into the pen and all breeding stock was killed. Prior to that occurrence, 53 immature wood ducks were released on Nantucket Island, in July and August. The island has no large timber and wood duck nesting records are rare. (The island also lacks large mammalian predators and has a mild climate.) In 1978, wood duck boxes were erected on 20 of the island's 100 or so ponds (Ed Metcalf, pers. comm.). Although the wood duck season was closed on the island in

1978, one female was reported as shot there. Two males from the island were also reported harvested, one in North and one in South Carolina. Poor ice conditions precluded box checks in 1979 and 1980 but at least three wood ducks were shot during the 1980 season, including two on release ponds (Ed Metcalf, pers. comm.).

In July 1978, Mr. Risch again gave the Division 52 wood ducks for release in Berkshire County. Five birds were killed on opening day of the Massachusetts waterfowl season near the Pleasant Valley Audubon Sanctuary release site in Lenox while a male was shot in South Carolina in December. One bird from a release made in Peru was taken in early October 1978 in Virginia. Release sites were not checked for box use.

The results of our releases of hand-reared birds indicate a higher success rate may be achieved by holding immatures overwinter and releasing them on potential nest sites in the spring. We found no evidence that birds released as adults returned to the vicinity where they were raised. Instead, we recorded six of the 16 hens we released as adults nesting on or near the point of release.

Our attempts to establish or supplement wood duck populations in Massachusetts proved to be costly and generally ineffective in producing increased wood duck populations. Since we raised wood ducks in conjunction with a black duck study (Heusmann *et al* 1979) initial costs were incidental but manpower requirements after July 1975 were solely for wood duck propagation. Our lack of success in hatching and rearing wood ducks artificially occurred despite following the recommendations of Doty (1972). The higher levels of nesting success achieved by allowing hens to incubate their own nests were thwarted by raccoon depredations.

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